Materials & Methods

Selection & use of

metals, nonmetallics, parts, finishes,

in product design & manufacture

January 1957

Hard Coatings and Surfaces for Metals—M & M Manual No. 134

Oxidation Resistant Rubber

Stepped Extrusions: a New Metal Form

Specifying Vinyls

Nickel-Free Austenitic Stainless Steel

New Uses of Magnesium

Phenolic Coatings for Metal Products

Complete Contents—page 1

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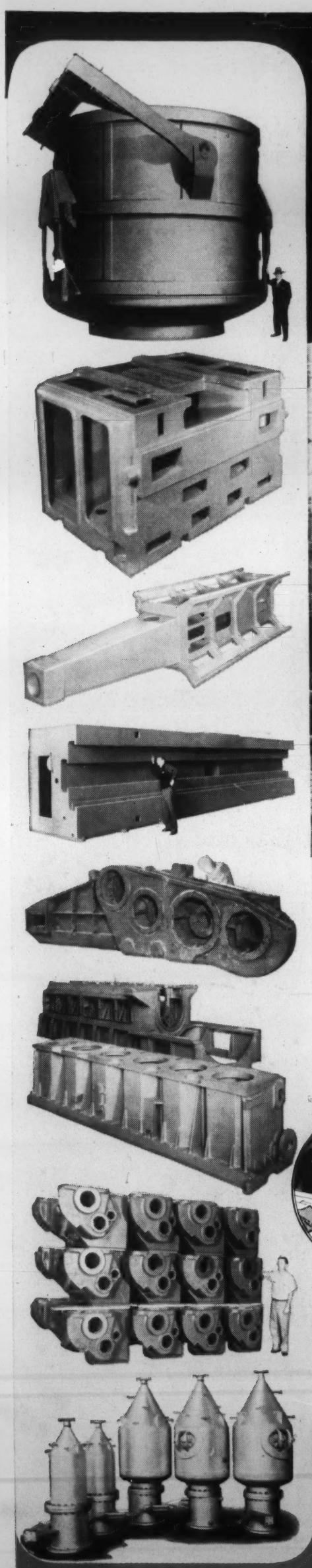

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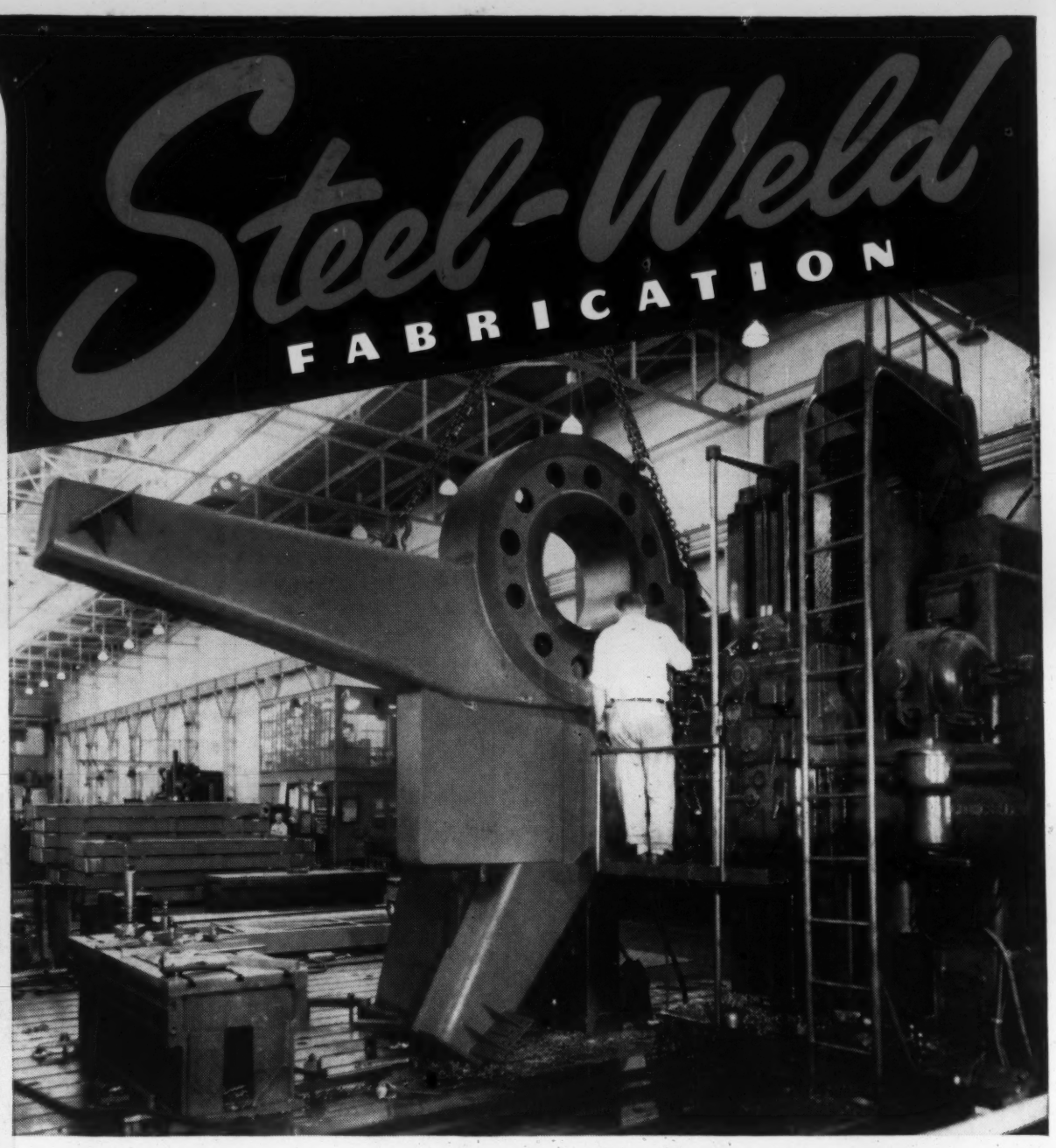

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Materials & Methods®

Selection & use of metals, nonmetallics, parts, finishes in product design & manufacture

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Easy does it. **At tagging station on Alaskan beach, a member of U. S. Fish & Wildlife Service steadies a three-month-old seal pup while companion attaches a corrosion-resisting Monel alloy tag to left flipper. Tagging permits tracing of seal migrations to various parts of the world, aids in scientific studies of growth, mortality, homing instinct and other characteristics.**

Tagged...for future reference

This little seal may be planning a trip far from his Alaskan home. But of course he can't tell the U.S. Fish & Wildlife Service what his destination is!

As they're very much interested in finding out, they tag him.

Migratory habits of seals have been under observance for many years. In all that time, there was one thing that always stumped the Wildlife Service—marking a seal so that he *stayed* marked.

They tried everything they could think of. Clipping...shearing...branding...painting. Nothing worked. When they tried metal tags, that brought up still another problem.

What metal would stand the abuse? What would resist corrosion from salt water? What would be hard enough to resist abrasion when seals clamber over rocks and sand?

Finally, a metal was found—Monel* nickel-copper alloy!

With Monel, it makes no difference if seals frolic in the salty sea. Or flip-flop around on shore. Or travel from Alaska to Japan, as many of them have! Monel alloy tags proved rugged enough to take this punishment. Some, in fact, remained in good condition *after 12 years on a seal's flipper.*

Do you have a problem involving metals? One in which corrosion, abrasion, high or low temperatures, stresses, or fatigue are causing trouble? Look into the Inco Nickel Alloys. Properties are described in a helpful booklet: *Standard Alloys for Special Problems.* Illustrated with more than 40 case histories. Write *now* for a copy. The International Nickel Company, Inc., 67 Wall Street, New York 5, N. Y.

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What's new IN MATERIALS

...AT A GLANCE

ONE OF BUTYL RUBBER'S DRAWBACKS, heat build-up, seems to have been overcome through the use of a chemical modifier that is claimed to double the resilience and strength of unmodified butyl rubber. The modifier may make possible a butyl rubber tire giving a softer, quieter ride than presently available tires.

ULTRAVIOLET LIGHT-ABSORBING PAINT, manufactured in Holland, finds use in industrial areas where welding torches are in constant use. The ultraviolet absorbing properties of the paint are said to greatly reduce harmful effects to the eyes of persons working in these areas. The paint is available in different types for use on cement, concrete, brick, wood, metal, asbestos and canvas.

A TANTALUM CARBIDE TARGET mounted on a zirconium oxide rod gives a brighter lamp for use in printing motion picture film. The lamp, which permits faster printing, has uniform brightness (within 5%) across the face of the target.

SYNTHETIC FUSED QUARTZ has a promising future in the electrical and nuclear fields. The synthetic quartz, with impurity levels of less than one part in ten million, has considerably better dielectric properties than natural quartz. Physical and chemical properties of the synthetic material are also better than those of the natural product. (See article in next month's issue for further details.)

PROCESSED LEATHER MAY BE CHEAPER as a result of a new process that utilizes a paper-like method of mass production for rolling a rubber latex and leather fiber mixture into a continuous sheet 52 in. wide. The processed leather is said to offer the appearance of real leather at half the cost of the natural product.

STRONGER REINFORCED PLASTICS may result from a new theory concerning the strength of discontinuous glass fiber-reinforced resins. The theory holds that 85-90% of the tensile strength of such laminates is due to the frictional resistance to slippage set up at the glass-resin interface when the resin shrinks against the glass during cure. Only 10-15% of the tensile strength is contributed by primary adhesion between glass and resin. Thus, it appears that the strongest laminates would be obtained

with resins strong enough to withstand without cracking whatever shrinkage occurs.

CLOSER TOLERANCE WROUGHT IRON TUBING, made by cold drawing instead of hot rolling, is now available. It is expected to find use in condensers, heat exchangers and similar applications where the good corrosion resistance of wrought iron could not previously be used to advantage because tolerances on diameter and wall thickness were too broad. (See article in next month's issue for further details.)

COTTON FIBER, YARN AND FABRIC will be exposed to high energy radiation to find out how much radiation can be absorbed by cotton without sacrificing its strength, elasticity, resilience and affinity for dyes. Attempts will be made to make some cotton fabrics more durable with radiation.

BERYLLIUM LOOKS PROMISING as a future aircraft material. If its inherent brittleness can be overcome, the metal can be used to make aircraft structures half as heavy as aluminum. (See article in next month's issue for further details.)

A NEW HIGH TEMPERATURE PLASTIC — an acetal resin — combines high tensile strength, toughness and good fatigue life with dimensional stability and solvent resistance. The experimental polymer is currently being field tested.

USE OF ORGANIC CHEMICALS AS COOLANTS in nuclear reactors may permit the construction of reactors made of a mild steel rather than expensive stainless steel. Recent tests indicate that monoisopropyl-biphenyl and biphenyl cause no corrosion of the reactor system. Since these solutions also pick up little radioactivity, it might be possible to reduce or even eliminate heavy shielding. Radiation damage to the organic compounds may be overcome by simple distillation.

CLAD ALUMINUM ALLOY IMPACT EXTRUSIONS are now possible through a new technique that clads aluminum during extrusion. The technique employs the Alclad process, applying a thin layer of aluminum alloy to provide cathodic corrosion protection or to provide a surface more suitable for decorative finishes.

PREIRRADIATED POLYETHYLENE SUITABLE FOR EXTRUSIONS is now available in limited experimental quantities. Its extrudability, as shown by current work on wire coating, is said to be similar to that of conventional polyethylene. Previously polyethylene had to be formed before irradiation. The new material may also be suitable for compression molding.

Turn to p 147 for more "What's New in Materials."

MATERIALS BRIEFS

Atomic Clock

Said to be accurate to within 5 sec in three centuries, a new atomic clock uses a cesium atom vibrating at some 9200 million megacycles.

Pickpocket-Proof?

Shark leather has been suggested for the manufacture of wallets. Since sharkskin has millions of tiny, sharp projections called denticles, the sharkskin wallet, if placed in the right position could give the prospective pickpocket artist a hard time; if placed wrong, it could give the owner a hard time.

Name in Lights

Sixteen interchangeable neon letters made of phenolic plastic have interlocking parts that permit easy fastening of the letters to an electrode holder, making it possible to word your own neon sign. The sign is waterproof and can be used outdoors.

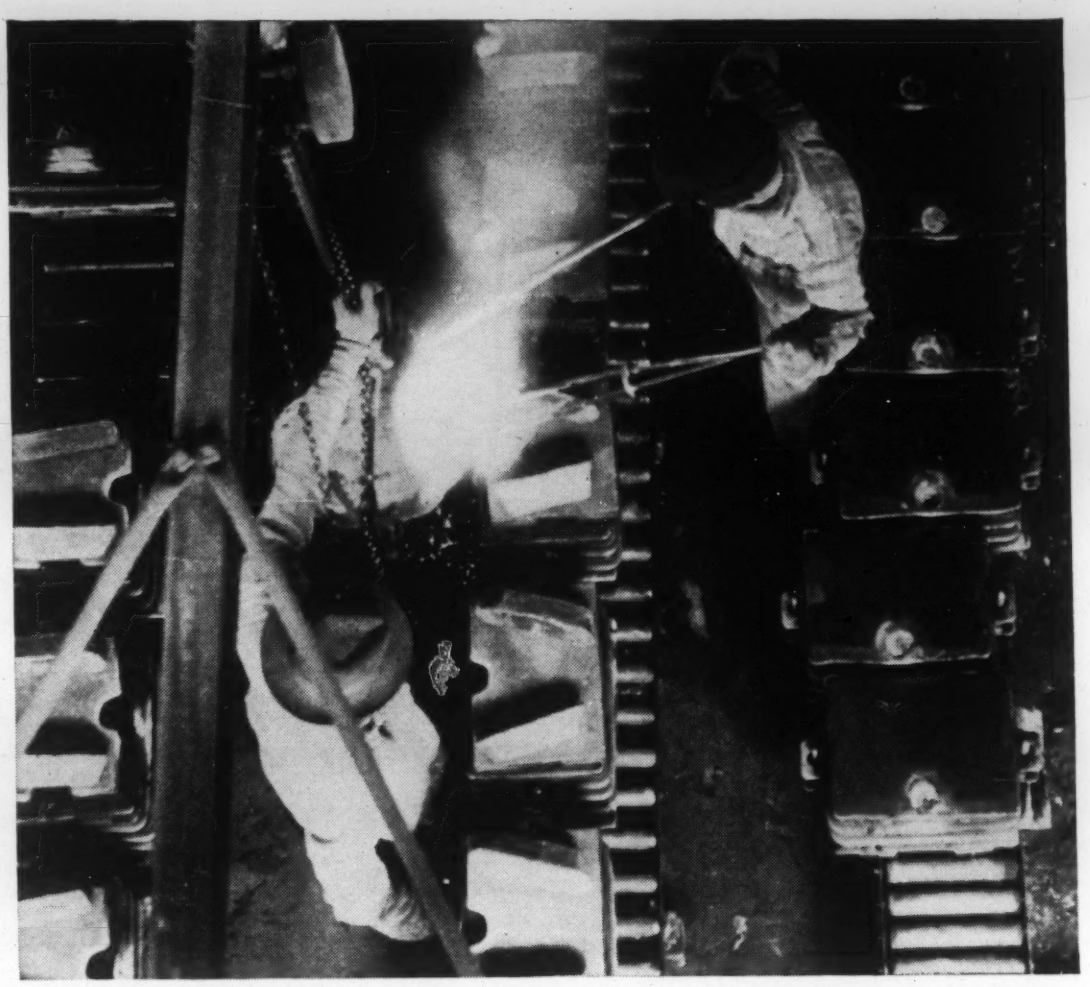
Caterpillar Boots

Caterpillar tractors can now travel over paved roads without serious damage to the road or the tractor by using rubber track shoes over the metal cleats. The rubber shoes can be left mounted on the tractor for surface ploughing and harrowing.

Carry a Spare

A portable bowling set uses 5-oz polyethylene pins and a 2-lb ball. The set is complete with backstop which also serves as a carrying case for the ball and pins.

Have you had trouble with Engineered Bronzes?



The truly engineered bronzes . . . silicon, aluminum and manganese bronzes . . . give desirable combinations of properties not available in any other metals.

If you need the physical characteristics of the engineered bronzes, but if you have had difficulty in achieving them in castings, it will be worth your while to try again with Federated products.

It is difficult to make these bronzes and only many years of experience and rigid quality control will produce the metallurgical qualities desired. At Federated, ingredient specifications are adhered to rigidly. Continual spectrographic and chemical controls are used during the alloying process. Experienced metallurgists are in charge. Performance specifications are always met or exceeded.

Let us tell you more about these valuable alloys. A Federated field man will be around to see you soon. Talk to him. It will benefit you.

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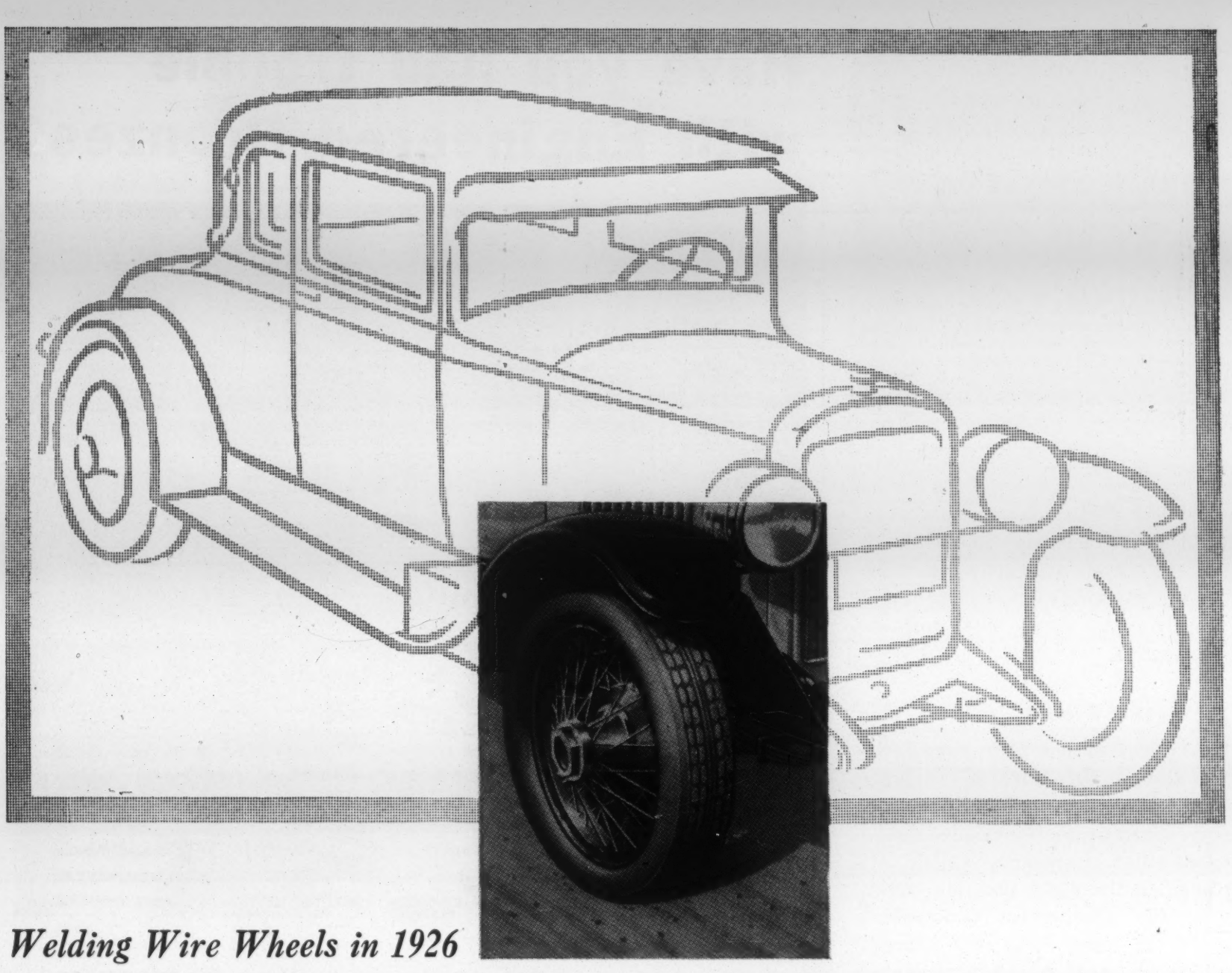

Welding Wire Wheels in 1926

Helped MALLORY Learn Better Ways to Solve Your Welding Problems Today

THIRTY YEARS AGO, a leading auto manufacturer (still a leader today) ran into a serious production bottleneck in resistance welding of wire wheels. The copper dies being used wore out so quickly that costs were too high, production too slow.

Elkonite®, a material developed by Mallory, looked promising for this application. It was tried . . . and the results were excellent. Die life increased tenfold. And production was freed of stoppage troubles.

This development marked Mallory's entry into the resistance welding field. It has been followed, in succeeding years, by a continuous stream of contributions to welding technology. These are some of the major milestones in Mallory progress:

Specialized alloys, like Elkaloy® A, Mallory 3, Mallory 22 and many others, which provide a family of materials engineered for the specific needs of welding service.

Fluted electrodes, which greatly increase electrode life.

Cold forming methods for producing bent electrodes with greater hardness and strength.

Special holder designs to meet the needs for higher pressures for large welding machines, and low pressures for non-ferrous alloys.

The knowledge gained during three decades of pioneering activity and constant development stands ready to serve on your own resistance welding problems. Write or call Mallory for a personal consultation by a Mallory welding engineer . . . and see your local Mallory welding distributor for prompt delivery of the best in welding electrodes, holders, seam welding wheels, forgings and supplies.

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For information on titanium developments, contact Mallory-Sharon Titanium Corp., Niles, Ohio.

For more information, turn to Reader Service Card, Circle No. 430

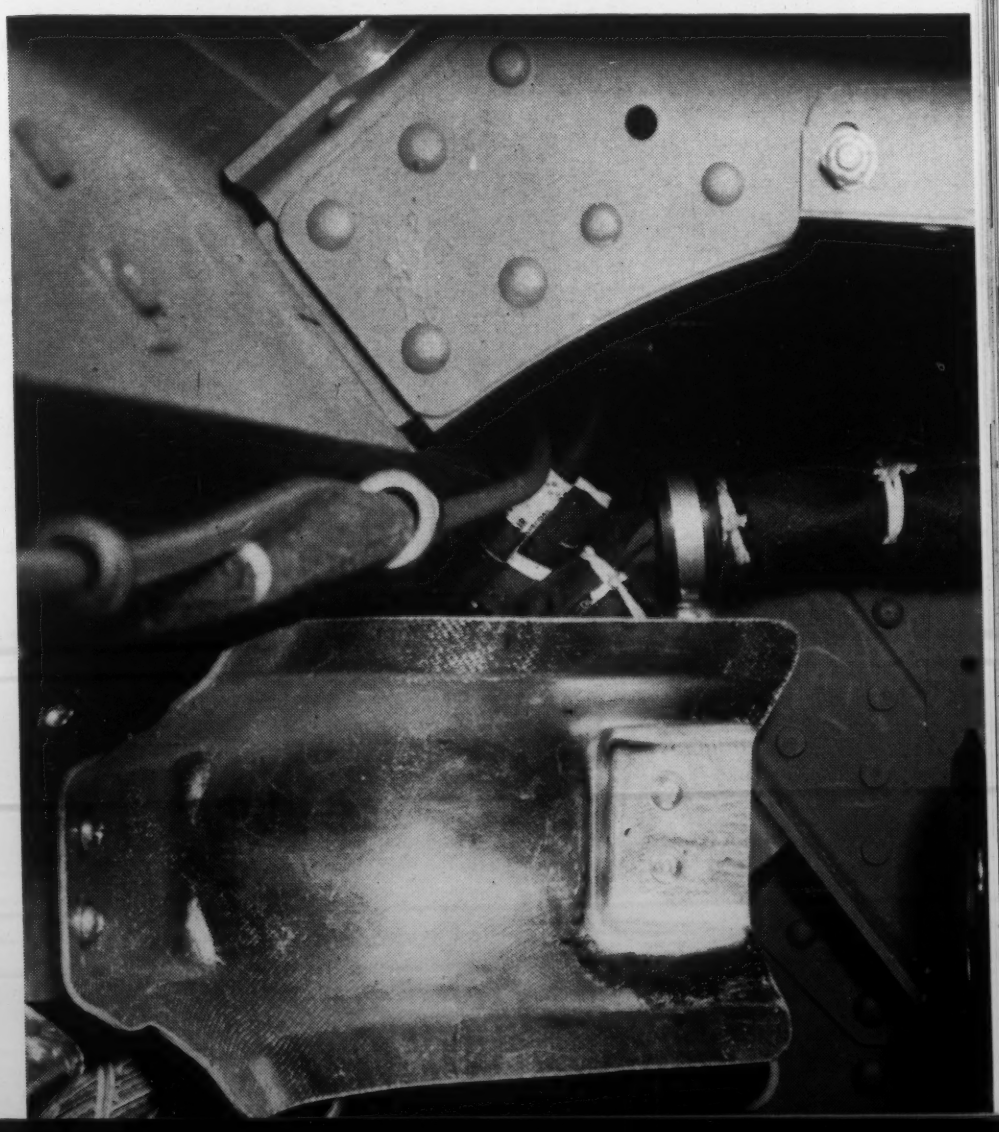
MATERIALS AT WORK

New and interesting applications of engineering materials

Metallized laminate protects wiring from heat

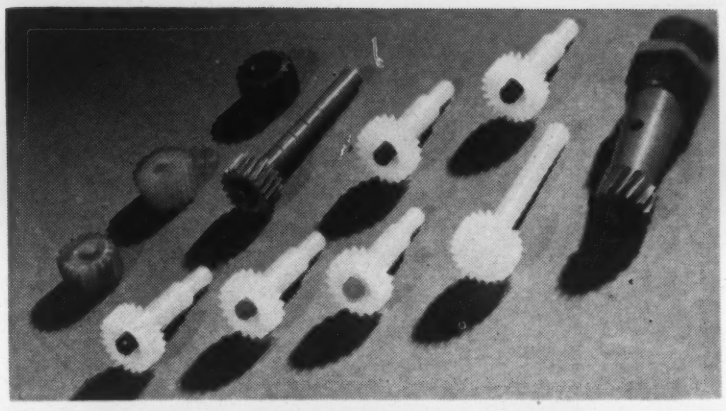
A glass-reinforced silicone laminate that is metallized to reflect radiant energy is reported to provide an efficient barrier to heat transfer at temperatures as high as 1200 F. The laminate is used as a shield to protect critical wiring from the tremendous heat generated in the afterburner area of North American Aviation's F-100 plane.

Effectiveness of the laminate is attributed to the combination of the low thermal conductivity provided by the glass fabric-reinforced plastics and the heat reflective surface provided by metallizing. Tests show a temperature drop from 1200 F on one face to 560 F on the other face, even after prolonged exposure. The lightweight laminate, manufactured by Swedlow Plastics Co., weighs 0.53 lb per sq ft, is 0.0626 in. thick, and is claimed to be easy to mold and fabricate.

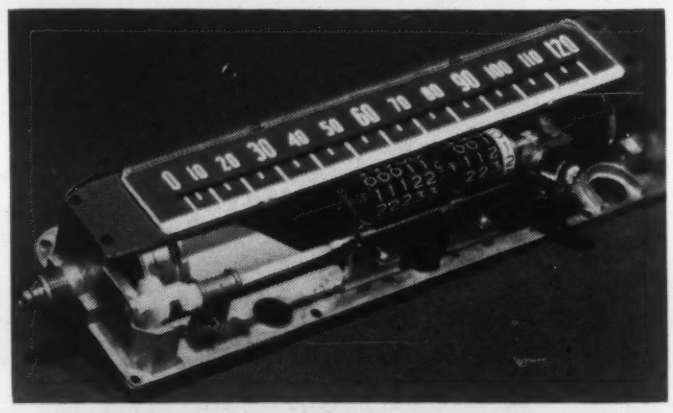


Some recent uses of nylon in cars include . . . gears

Since 1950 the use of nylon in automobiles has increased by over 700%, according to figures supplied by Du Pont. The growing importance of nylon as an engineering material in the automotive industry stems from its excellent combination of properties and the ease with which it can be economically molded into a variety of intricate forms and shapes. Nylon is resistant to extremes of temperatures and can be safely boiled, steam sterilized or subjected to subfreezing temperatures. It is exceptionally resilient and has high tensile, flexural and impact strengths. It resists abrasion and all common chemicals, greases and solvents (except mineral acids). It has excellent electrical properties, a low coefficient of dynamic friction and is self-lubricating. Nylon is presently being used in the automotive industry for such things as door wedges, seat stops, window rollers, domelight lenses, coil forms, gearshift selector panels, etc. On these pages are some other recent applications.

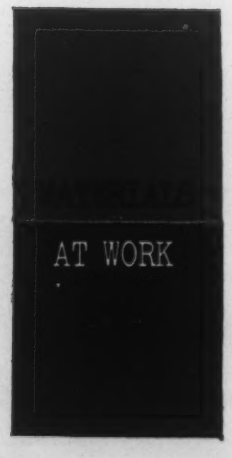


Take-off gears and shafts *are economically mass produced by injection molding. Quietness of operation, long life and lack of lubrication problems are primary reasons for using them as the . . .*

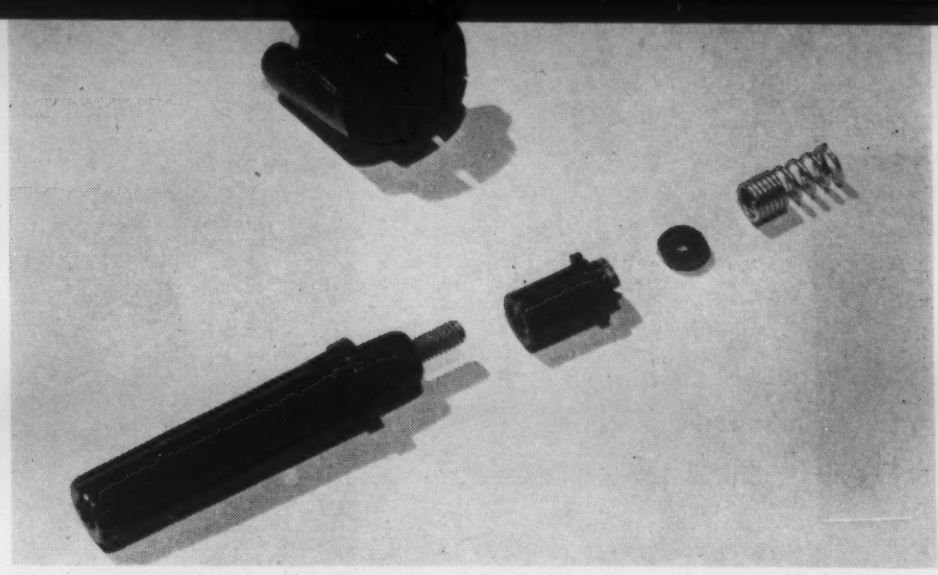


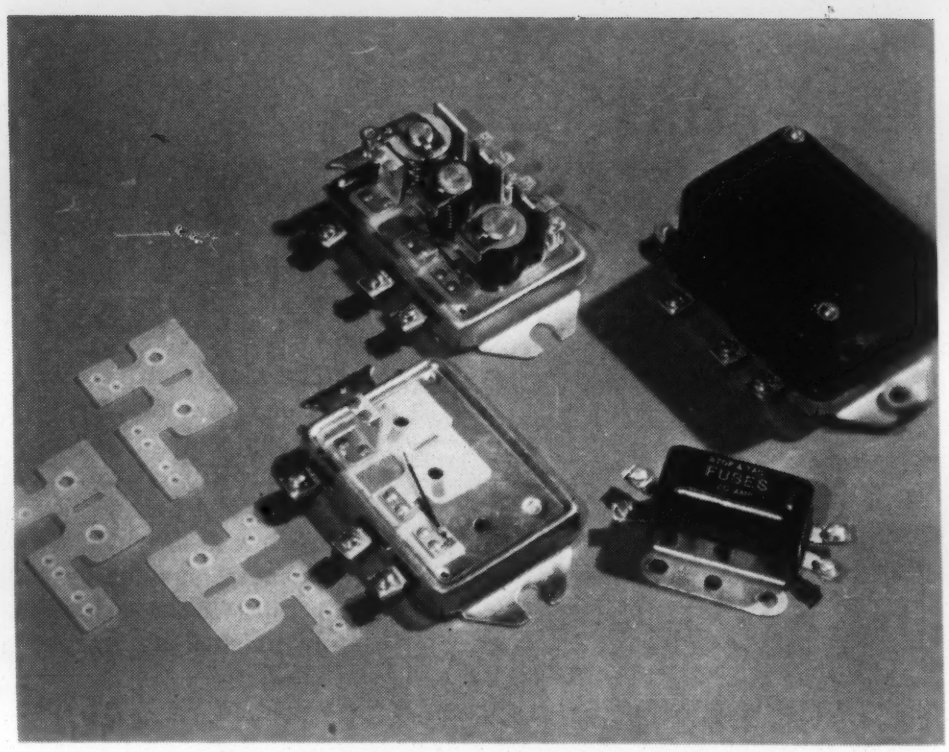
. . . speedometer *driving gear, pinion and adapter shown here. The nylon gears showed no perceptible wear after a 48,000 mile road test. Quiet operation in an electric . . .*

. . . windshield wiper motor *is achieved in part by the use of a large nylon gear driven by a metal worm mounted on the motor shaft.*



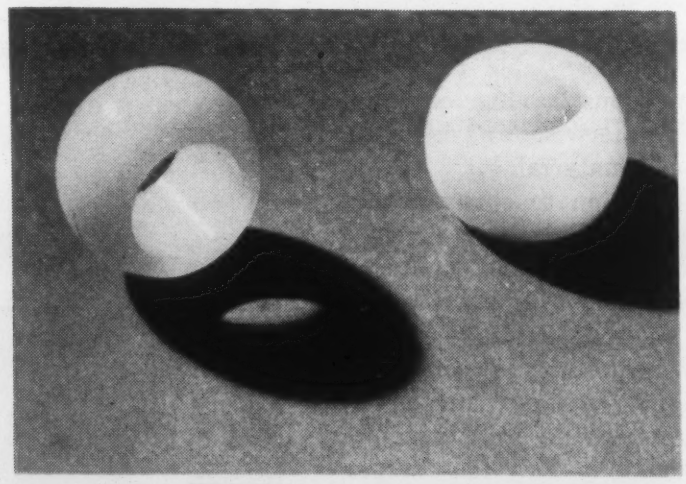
electrical insulation

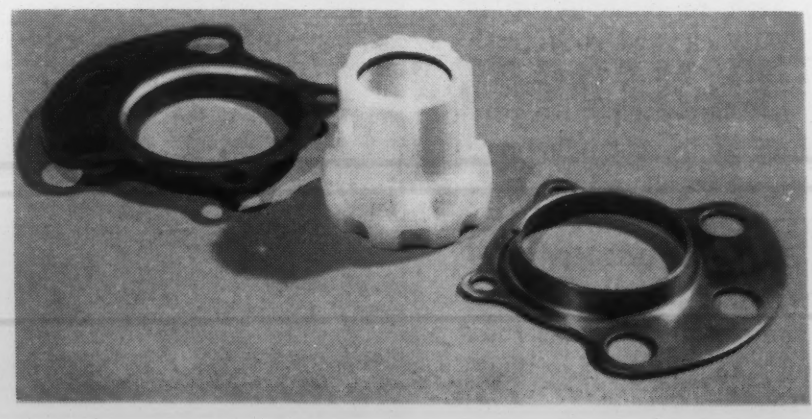




Fuse holder *(above) provides excellent insulation at automotive voltages, and has adequate heat resistance and toughness. The insulating section of the voltage regulator base (below) not only provides necessary electrical insulation but acts as a rigid chassis for the assembly of the various electrical components. Tedious hand insertion of insulating sleeves for each mounting rivet is eliminated. The fuse box cover (lower right) is molded of black nylon. Electrical properties as well as toughness are responsible for its use here.*

bushings and bearings





Clutch cross-shaft bearing *(left) operates without lubrication and is not vulnerable to electrolytic corrosion. It is unaffected by gasoline, oil or grease and holds up well under the abrasive abuse to which it is subjected. The bushing shown at right is used in the brake camshaft assembly and can be operated continuously to 250 F or in subzero temperatures.*

MATERIALS AT WORK

Reel lasts longer with Flame-Plated guide pin

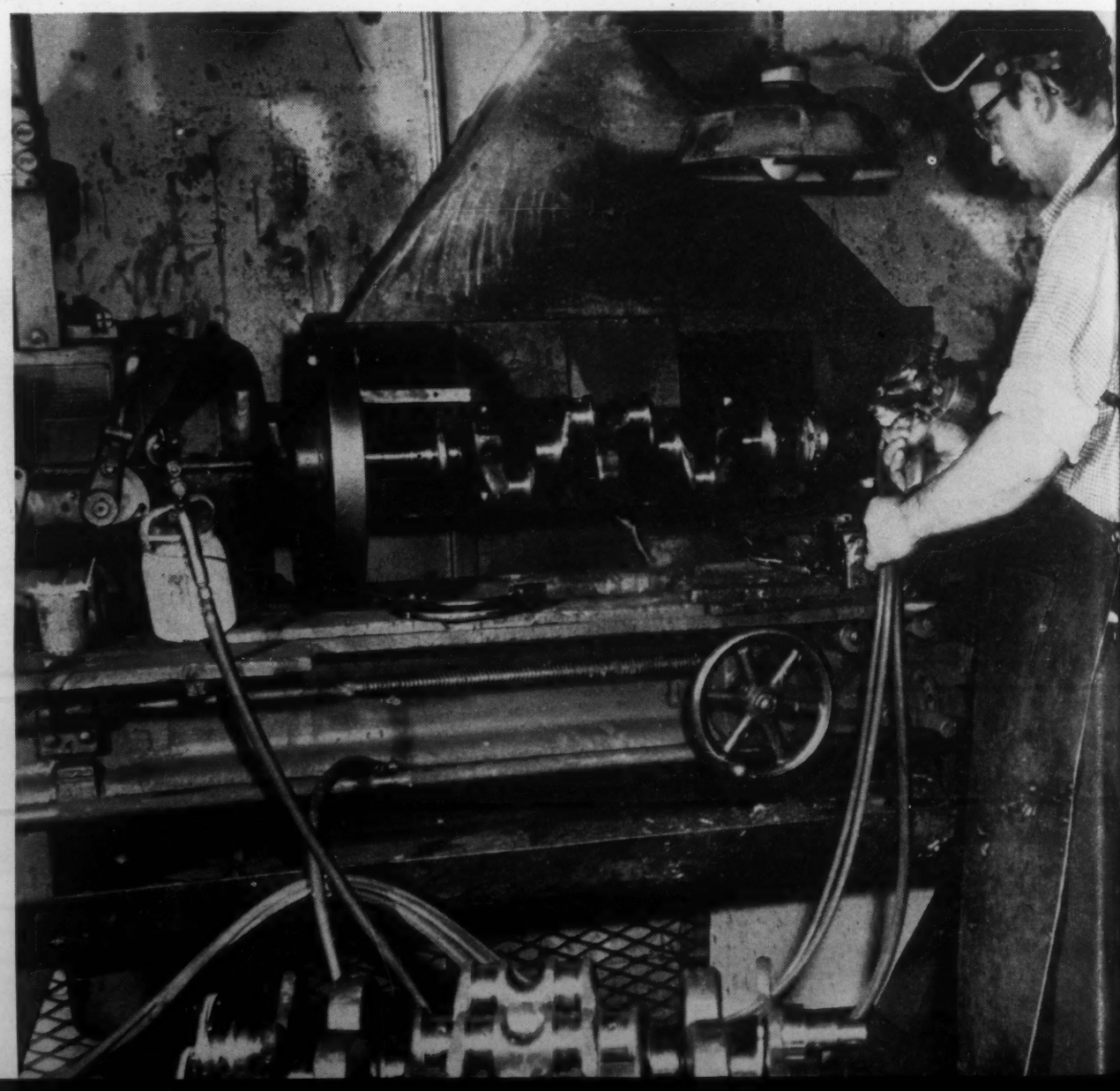
The aluminum face of this spinning reel (shown in the cutaway portion) controls the return of the fishing line and is subject to constant wear. In order to increase the wear life of the spinning reel, Zero Hour Bomb Co. is now having the guide pin and the area immediately around it Flame-Plated with tungsten carbide. The Linde process, which deposits tungsten carbide or aluminum oxide on a metal surface by controlled detonation, provides a hard, wear resistant surface which can be left as coated—125 microinches rms —or finished as smooth as 0.5 microinches rms.

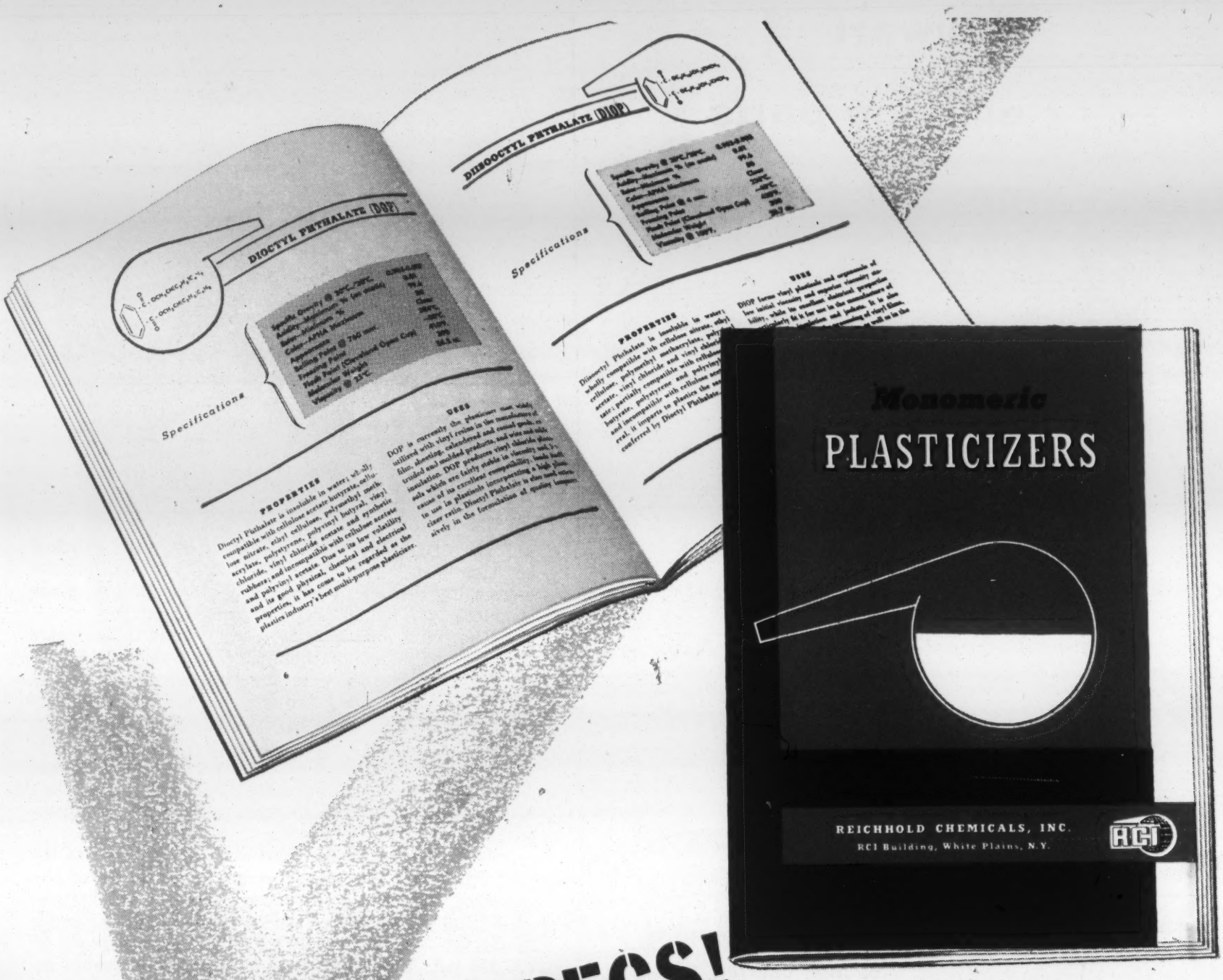
Auto crankshafts salvaged by metallizing

By turning to the metallizing process in order to salvage a stockpile of improperly ground crankshafts, American Motors Corp. has been able to realize a tremendous saving on what would otherwise have been scrapped material.

The decision to spray crankshafts with molybdenum resulted from extensive tests conducted by Metallizing Engineering Co. which showed conclusively that quality requirements could not only be met but often surpassed.

The metallizing work is simple and consists of only four steps: 1) the area to be built up is mechanically cleaned with fresh emery cloth; 2) portions adjacent to the work area are masked off to prevent adherence of metal where it would have to be removed; 3) pure molybdenum is applied 0.010 to 0.010 in. thick with a metallizing gun; and 4) the metallized crankshaft is ground to final dimensions.





CHECK THE SPECS!

RCI OFFERS A COMPREHENSIVE LINE OF QUALITY MONOMERIC PLASTICIZERS

• When you need a monomeric plasticizer for cellulosic or vinyl resins, RCI can help you. Specifications for these RCI plasticizers offer convincing proof of their quality.

Because impurities responsible for inferior end products have been removed, these RCI materials feature a high degree of plasticizing efficiency. Your own laboratory and plant tests will demonstrate that RCI plasticizers are not only unusually stable, but also display a pronounced resistance to detergent extraction.

Write for the catalog on RCI Monomeric Plasticizers illustrated above. Attach the coupon at right to your letterhead. When you've read the catalog, send for a free sample of any plasticizer you want to test after studying the specifications. Included in this RCI line are:

Dibutyl Phthalate	Didecyl Phthalate	Dibutyl Sebacate
Dioctyl Phthalate	Butyl Decyl Phthalate	Dioctyl Sebacate
Diisooctyl Phthalate	Dioctyl Adipate	Diisooctyl Sebacate
Dicapryl Phthalate	Didecyl Adipate	
Octyl Decyl Phthalate	Dibutoxyethyl Adipate	Dibutyl Fumarate

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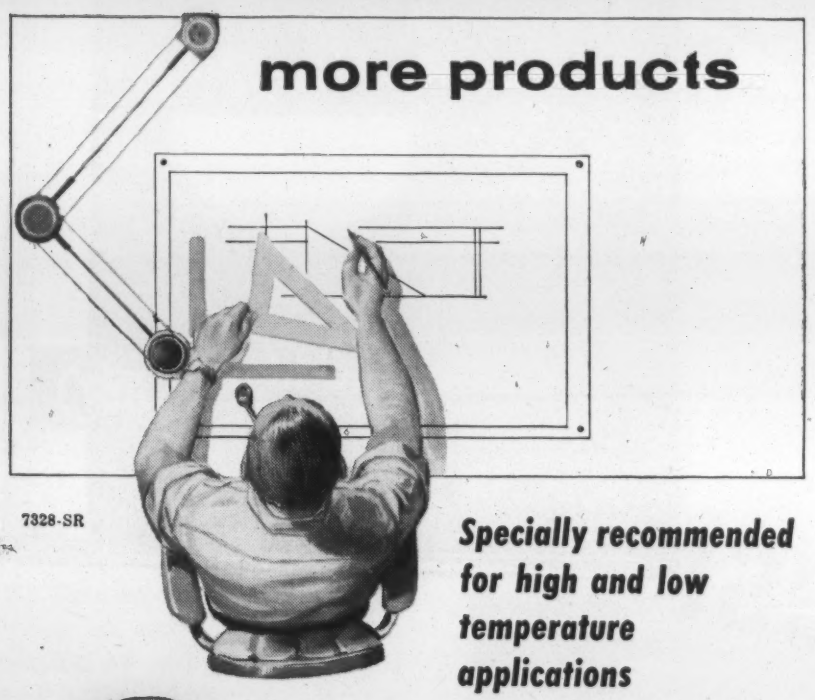
Stalwart silicone parts are solving more and more engineering problems for more and more products



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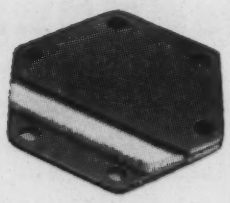

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A reader criticizes . . .

To the Editor:

In regard to the article entitled "Cold Worked 301 Stainless," Sept '56, p 100, we believe that the curves for tensile strength vs temperature place stainless 17-7 PH in an unfavorable light.

The room temperature tensile strength indicates that the material is either partially rolled (½H) or tested in the annealed and overaged condition (TH 1050). Data obtained for these conditions are then plotted in comparison with type 301 full hard. Since type 301 has been rolled to a reasonably high tensile strength, we believe that data for 17-7 PH should be presented on a similar basis. Therefore, the rolled and aged condition (CH) would offer a fairer comparison.

In the case of cold rolled and heat treated (CH) 17-7 PH strip, the tensile strength would be of the order of 260,000 psi at room temperature, instead of 180,000 psi as shown. At 800 F the tensile strength would be approximately 205,000 psi instead of 123,000 psi. For other temperatures, comparable increases would apply. . . .

J. T. RICHARDS
Penn Precision Products, Inc.
Reading, Pa.

. . . and the author replies

To the Editor:

The properties of full hard 301 were compared with AM-350 and 17-7 PH hardened by heat treatment because they have approximately the same ductility in this state. AM-350 as well as 17-7 PH can be hardened to approximately 260,000 to 280,000 psi tensile strength by cold rolling and aging, but the elongation drops to approximately 1 to 3%. At this ductility level, 301 cold rolled 65% develops tensile strength of 250,000 to 260,000 psi.

R. A. LULA
Allegheny Ludlum Steel Corp.
Pittsburgh, Pa.

More on engineers' aides

To the Editor:

In the Nov '56 issue Mr. Rosenberger suggested the use of engineers' aides to help alleviate the engineer shortage. The U. S. Government has had such a plan for several years.

I am an Engineering Aide, GS-7 (electronics) and have been for five years, ever since I had to leave college before graduating. I have had plenty of opportunity to use my skills to full advantage. Recently I have been doing work on an engineering level but because of Civil Service regulations I cannot be rated as a professional engineer without considerable difficulty. However, an Engineering Aide

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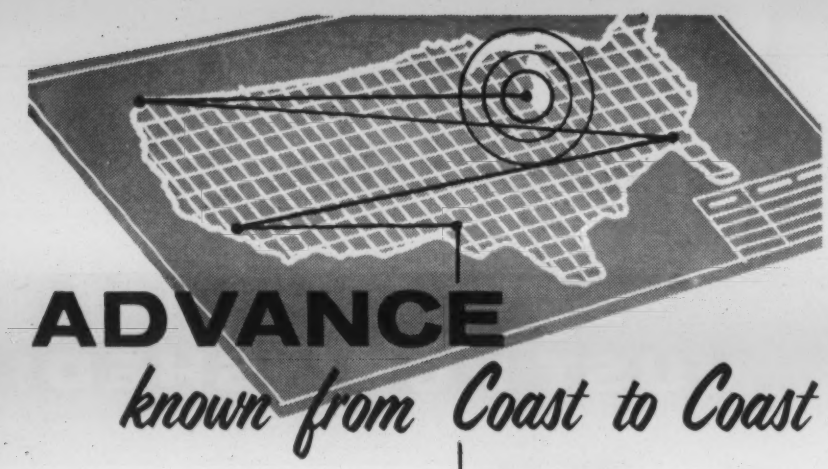

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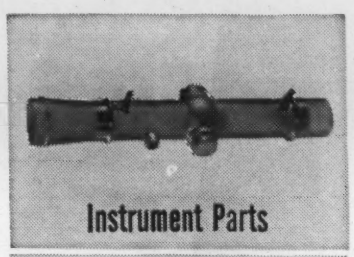

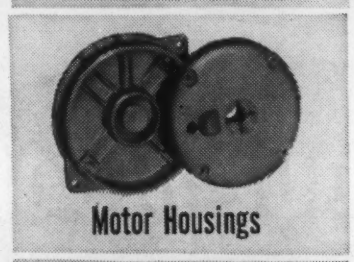

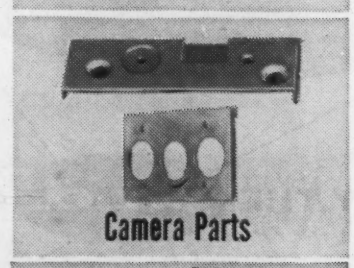

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In the Laboratory where I work, I'd say about 10% of the technical people are aides. I would estimate that there is one for every four or five scientists or engineers. There are physicist aides as well as engineering aides.

I would say that most science and engineering students who leave college before graduating would be glad for a chance to work as aides. It's far better than digging ditches or selling vacuum cleaners for a living. I am in full agreement that engineering aides would be capable of performing many of the duties of engineers. In fact, there have been occasions when an aide has been able to take over a project during the project engineer's illness. As for a supply of these people, start recruiting the people in college ready to drop out. There are nearly as many students who drop out as graduate.

RAYMOND T. SOREL
U.S.N. Underwater Sound Laboratory
New London, Conn.

Old manuals never die

To the Editor:

I want to thank you for permission to reproduce 100 copies of MATERIALS & METHODS Manual 8, "Standard Engineering Steels" by Charles M. Parker, which we are using in a training program for the 9256th Air Reserve Squadron, Newark Air Reserve Center, Newark, N. J. The Institute was asked to have its staff deliver five lectures, including one on the uses and properties of steels for which the manual is very helpful.

JOHN W. W. SULLIVAN
Metallurgical Engineer
American Iron & Steel Institute
New York, N. Y.

Article reprints

To the Editor:

We are very interested in the article "Plastics Pipe," which appeared in the Aug '56 issue. If reprints are available, we would be interested in obtaining them, as we felt your article was one of the most comprehensive we have ever read on the subject. We would be interested in quantities up to 50; however, if only smaller quantities are available, we will take what you can send.

Please advise us of the cost and availability of these reprints.

Barber-Webb Co., Inc.
Los Angeles, Calif.

Inquiries concerning reprints are frequently received and we would like to clear up a few points. Our Reader Service Dept. handles requests for single reprints free of charge as long as the very limited supply holds out. Volume requests are usually handled by making new copies by the photo-offset method. An idea of the price can be obtained from these approximate figures for a four-page article: 100 reprints, $60.00; 1000 reprints, $78.00.

ONE POINT OF VIEW

The engineer shortage is not as bad as it looks

Few will disagree that there is a shortage of engineers. We couldn't possibly forget it. Almost daily we hear speeches or read articles and editorials on the subject, most of them in the shrill tone of impending disaster. Although it would be fashionable for us to echo the sentiments of the majority, we believe that the seriousness of the engineer shortage has been greatly exaggerated and that the future outlook isn't as bad as many would have us believe.

It's not industry-wide

First, let's consider the present shortage. It is true that today there are not enough engineers to fill the needs of industry. But the shortage is critical in relatively few fields. Outside of electronics, aircraft and a few other specialties, the shortage is not critical, and except for these fields, it is only temporary.

Nor does the shortage loom as large in the over-all view as many after-dinner speakers like to suggest. According to the Engineers Joint Council, we should have graduated from 35,000 to 40,000 engineers last year to fill present needs. Estimates indicate that about 30,000 received first degrees in 1956. This leaves a shortage of 5000 to 10,000. Since the total number of engineers today is about 700,000, last year's annual shortage of graduating students amounts to only 1 or 2% of total engineers employed.

More college students . . .

It is frequently pointed out that the number of engineering graduates has dropped during the past five years. But this decline has not been limited to engineering graduates. The total number of all persons graduating from colleges also declined from 1950 to 1956, simply because a smaller number of people reached college age during this period. The number reaching college age began to increase last year and by 1965 our college age population will be 30% greater than in 1956.

. . . and more are engineers

A more significant aspect of the shortage is that in recent years there has been a decline in the percentage of students choosing to study engineering. In 1948, 11% of all first degrees granted were in engineering as compared with 8% in 1955. Although this decline is not to be passed over lightly, it is encouraging to note that the downtrend was arrested in 1954, and that 1955 (and probably 1956) showed an upward trend again.

What of the future? Most of the pessimists cite the greatly accelerated pace of our technical advancement and the danger of our not being able to produce enough engineers to meet the resulting demand.

History is encouraging

But we have seen that the proportion of engineers among college graduates is again on the rise. In addition, we can make a reliable assumption that the proportion of engineers in the population or among total employed will increase as demanded by our technical age. From 1930 to 1956 the number of engineers has grown more rapidly than almost any other aspect of our economy. The number per 10,000 population has doubled and the number per 10,000 employed has nearly tripled.

We believe that such figures may be used with some assurance to predict that the engineering profession will continue to keep pace with the demands of industry in the future.

Where to Use Hypalon

Here is a detailed report on this chlorinated polyethylene rubber

by B. W. Fuller, *Elastomers Laboratory, E. I. du Pont de Nemours & Co., Inc.*

■ The most important property contributing to the growing use of Hypalon synthetic elastomer (see M&M, May '53, p 104) is its extreme resistance to oxidation, whether as a result of sunlight and weather, chemicals, high temperatures or ozone concentrations. Combined with this property are good mechanical properties and unlimited colorability. These properties are available to the designer in molded or extruded parts, and in coatings for other materials. (Hypalon can also be used to upgrade other synthetic rubbers.) In the four years since its development, the chlorosulfonated polyethylene elastomer has found important applications in both forms.

1. For molded and extruded parts . . .

Uses of molded or extruded Hypalon parts have been dictated by the material's ability to withstand the extremes of specific service conditions.

Ozone resistance of Hypalon is exceptional. This is an important factor not only for special application of the elastomer but also in its resistance to outdoor exposure, since ozone is the cause of cracking and failure of rubber when exposed to sunlight and weather. Several hundred specimens have been stretched amounts ranging up to 250% elongation and exposed in these stressed conditions to ozone concentrations of up to 10,000 ppm at temperatures up to 160 F. No specimen showed any ill effect after exposure periods of up to 72 hr. Specimens exposed up to 30 months in both laboratory and outdoor weathering tests also showed negligible effects on both properties and appearance. Specimens colored with stable pigments that screen or absorb ultraviolet light showed no discoloration.

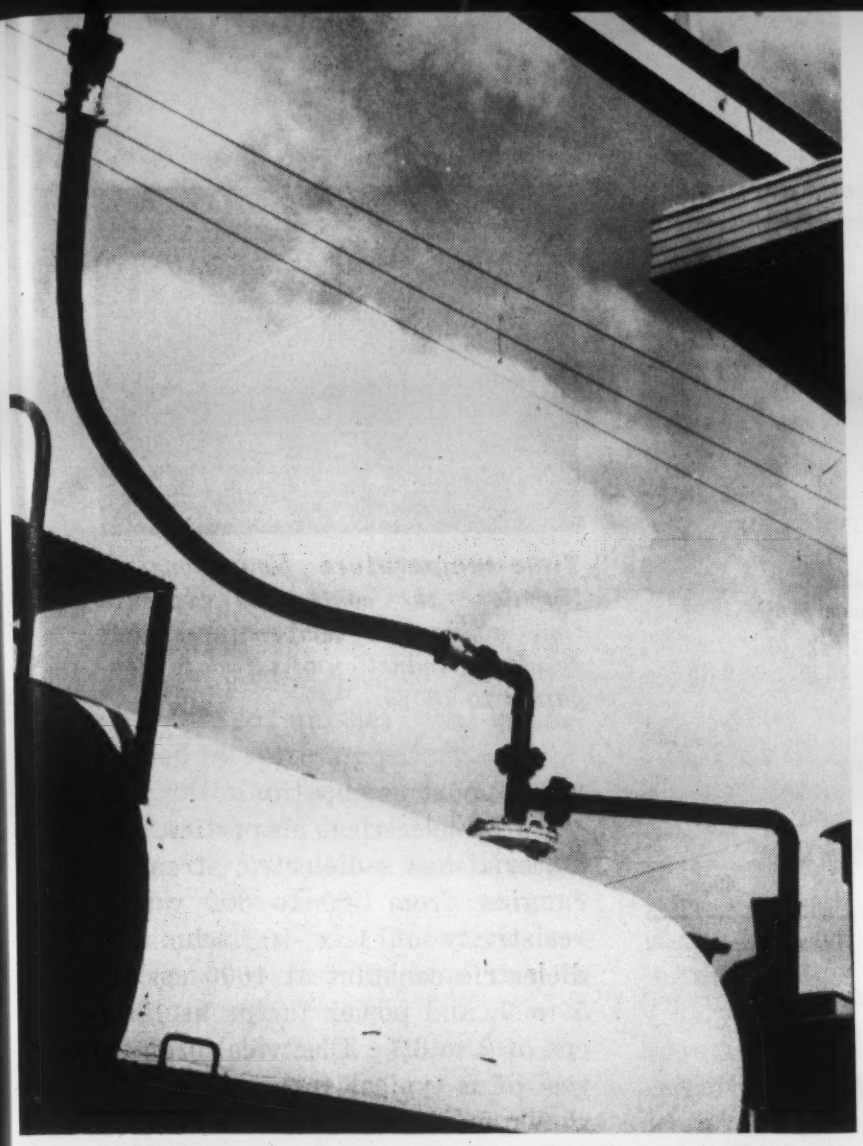
Hypalon's unusual ozone resistance makes it useful for such severe applications as head gaskets for commercial ozone generators. In one such application Hypalon gaskets have been exposed to 1-2% ozone concentrations for over two years without failure. Other applications making use of this resistance to ozone attack are: electrician's blankets that protect workers from hot lines, outdoor floor tiles, extension cords, and other rubber products that are normally exposed outdoors in a stressed condition.

Chemical resistance of the elastomer is good, particularly its resistance to strong oxidizing chemicals. Table 1 groups some common chemicals according to the severity of their attack on Hypalon. The table is only a guide and should not be construed as a final recommendation. Although not classified as an oil resistant rubber, Hypalon has relatively good resistance to oils and grease. However, it is not recommended for applications involving contact with either aromatic or chlorinated hydrocarbons.

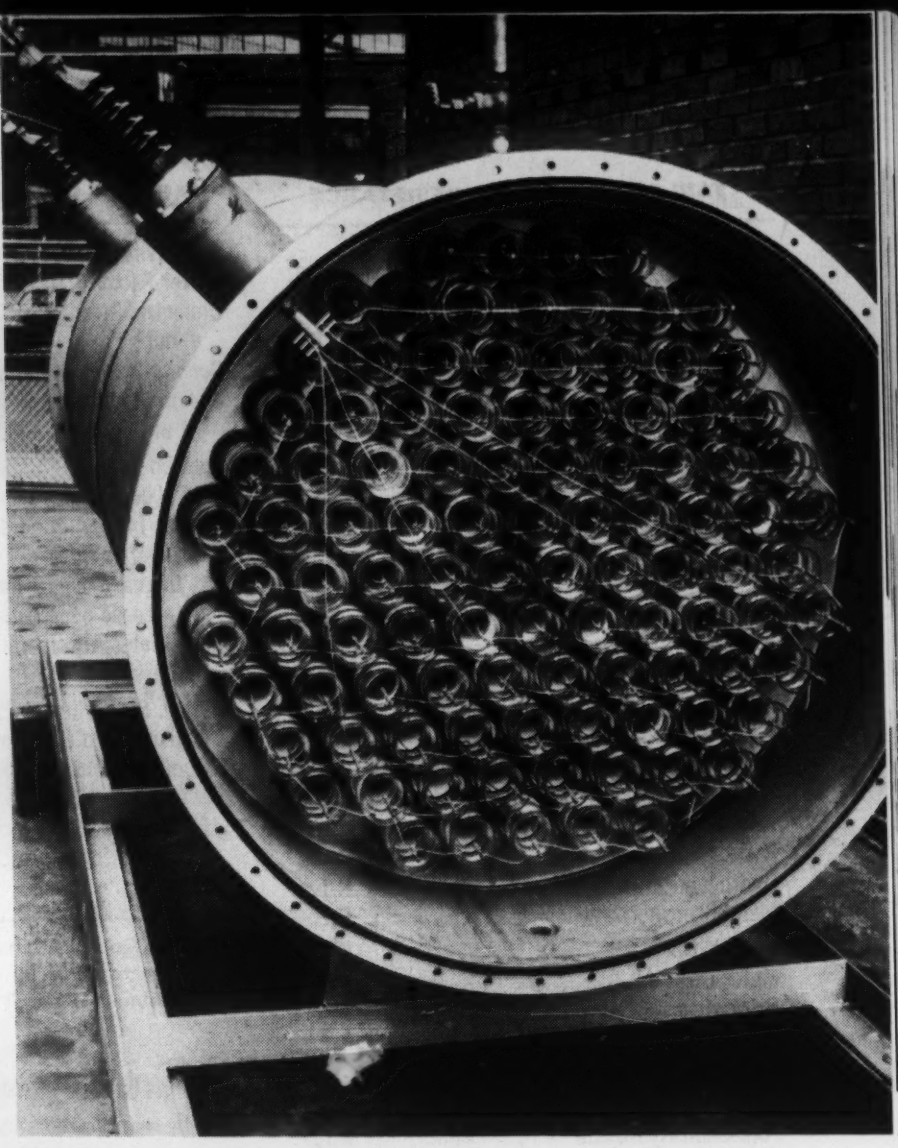
Because of its chemical stability, Hypalon is particularly suitable for use in hoses, valves and gaskets exposed to concentrated sulfuric and chromic acids, hydrogen peroxide, calcium hypochlorite and other strong oxidizing agents. In an electroplating plant, a Hypalon hose has been handling plating solutions containing 40% chromic acid by weight at temperatures around 105 F for 2½ years without deterioration.

A 6-in. butterfly valve lined with the elastomer has been successful in handling spent acids on a waste disposal truck. The valve consists of an acid resistant metal damper which rotates in a ring-piece lined with a Hypalon sleeve slightly smaller in diameter than the damper. When closed, the metal disk squeezes tightly against the resilient rubber, forming a pressure-tight seal. To date, the sleeve has withstood more than two years of service.

High temperature stability of the material is comparatively



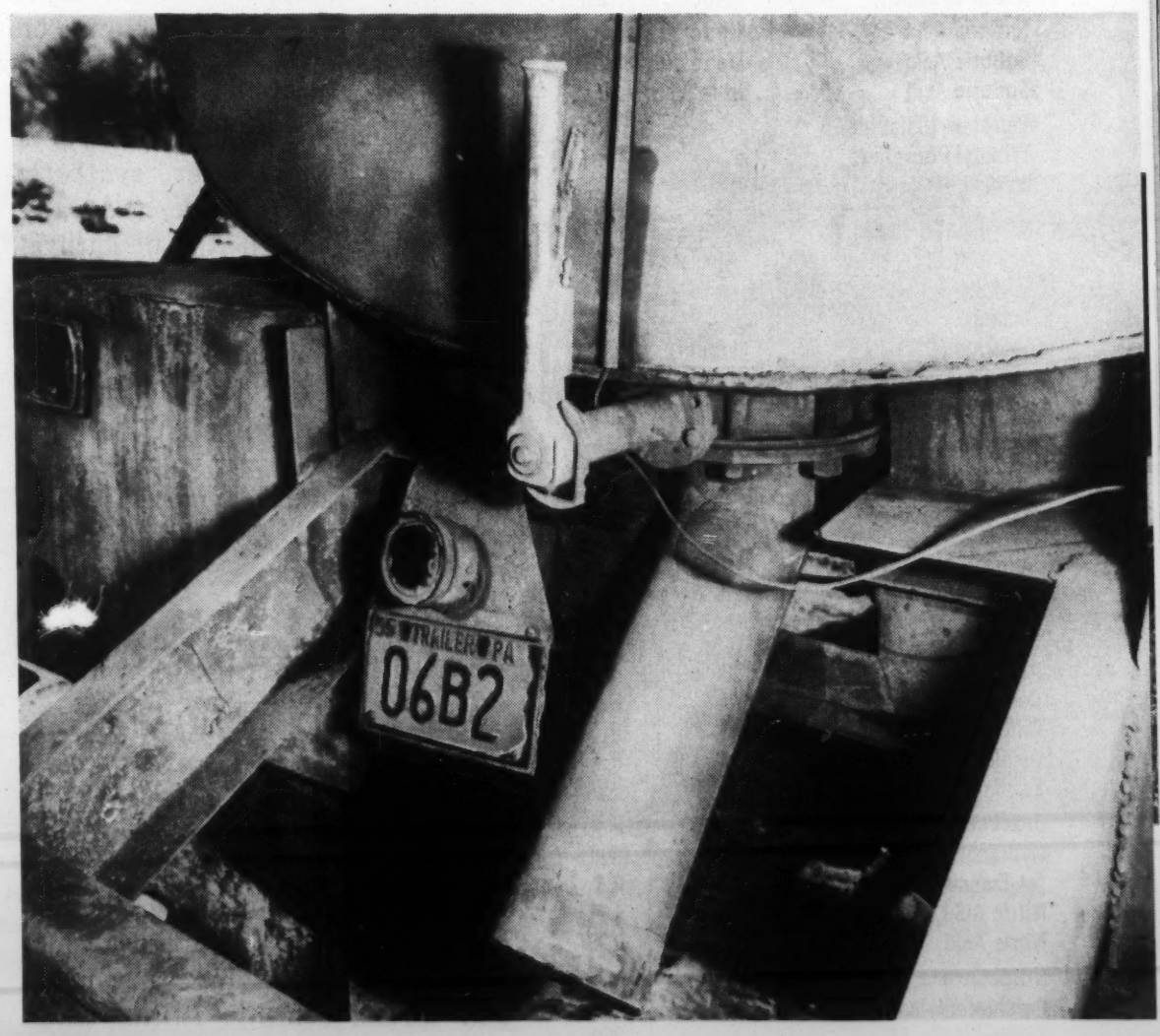
Acid hose *lined with Hypalon has been handling sulfuric acid for over two and a half years and is still in good shape.*



Head gaskets *extruded from Hypalon have been used on commercial ozone generators for three years. None has failed in service because of ozone attack.*

good. It can normally be used continuously at temperatures up to 200 F, and for intermittent service at 250 F. Formulations can also be obtained for continuous service at 250 F and intermittent service at 300 F. An accompanying graph shows how long a typical composition can be continuously exposed to given temperatures before its ultimate elongation drops to 100% (e.g., about three months at 250 F).

Because of their heat resistance, Hypalon moldings are currently being used as spark plug boots on a V-8 engine. The elastomer is also being used successfully in conveyor belts handling hot materials. In one chemical plant, an elevator belt covered with the elastomer receives hot salt from the discharge end of a direct fired rotary drier and lifts it 27 ft upward to storage at the rate of 188 fpm. Temperature of the salt as it falls from the drier onto the belt averages about 300 F, though peaks of 500 F have been recorded. The belt is equipped with monel buck-



Butterfly valve *with Hypalon lining is used on this truck, designed for disposal of spent acids.*

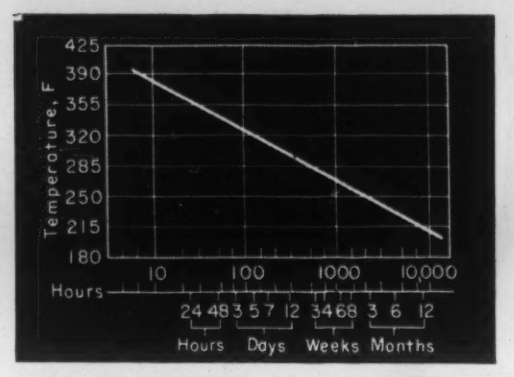
TABLE 1—CHEMICAL RESISTANCE

Chemical	Conc by Wt, %	Temp, F
LITTLE OR NO EFFECT:		
Ammonia	Liquid anhyd.	R.T.
Chlorine Dioxide	14	150
Chromium Plating Soln.	—	158
Chromic Acid	50	200
Chromic Acid	Conc	R.T.
Cottonseed Oil	—	R.T.
Diethyl Sebacate	—	R.T.
Dimethyl Ether	—	R.T.
Ethylene Glycol	—	158
Ferric Chloride	15	200
Ferric Chloride	Saturated	R.T.
Formaldehyde	37	R.T.
Freon-12	—	R.T.
Hydrochloric Acid	37	122
Hydrochloric Acid	48	158
Hydrogen Peroxide	50	212
Hydrogen Peroxide	88.5	R.T.
Methyl Alcohol	—	R.T.
Mineral Oil	—	R.T.
Motor Oil (SAE 10)	—	R.T.
Nitric Acid	Up to 20	158
Nitric Acid	70	R.T.
Phosphoric Acid	85	200
Pickling Solution	20 HNO_3, 4 HF	158
Potassium Hydroxide	Conc	R.T.
Sodium Dichromate	20	R.T.
Sodium Hydroxide	20	200
Sodium Hydroxide	50	158
Sodium Hypochlorite	20	200
Stannous Chloride	15	200
Sulfur Dioxide	(Liquid)	R.T.
Sulfuric Acid	Up to 50	200
Sulfuric Acid	Up to 80	158
Sulfuric Acid	Up to 95.5	R.T.
Tetrabutyl Titanate	—	R.T.
Tributyl Phosphate	—	R.T.
Water	—	200
MODERATE EFFECT:		
Acetic Acid	Glacial	R.T.
Acetone	—	R.T.
Aniline	—	R.T.
Chlorine (Dry)	(Liquid)	R.T.
Cottonseed Oil	—	158
Diethyl Ether	—	R.T.
Hydrochloric Acid	37	158
Mineral Oil	—	212
Motor Oil (SAE 10)	—	158
Nitric Acid	70	122
Sulfuric Acid	95.5	122
Turbo Oil No. 15	—	R.T.
SEVERE EFFECT:		
Acetic Acid	Glacial	158
Carbon Tetrachloride	—	R.T.
Citrus Oils	—	R.T.
Dichlorobutene	—	R.T.
Formaldehyde	37	158
Gasoline	—	R.T.
Hydrochloric Acid	37	200
Jet Engine Fuel (JP-4)	—	R.T.
Nitric Acid	30	158
Nitric Acid	Fuming	R.T.
Nitrobenzene	—	R.T.
Perchlorethylene	—	R.T.
Turbo Oil No. 15	—	350
Xlyene	—	R.T.

TABLE 2—ELECTRICAL PROPERTIES[a]

Resistivity (d.c.), ohm-cm	1 x 10^{14}
Power Factor (1000 cps)	3–4
Dielectric Strength (0.075-in. sheet), v/mil[b]	500
Surface Resistivity, ohms	1 x 10^{13}
Specific Insulation Resistance (K at 60 F), per 1000 ft	22,000
Specific Inductive Capacity:	
At 1000 cps	6–7
After 14-day immersion in 158 F water:	
Increase over 1-day value, %	3
Increase over 7-day value, %	1
Mech Water Absorp (after 7-day immersion at 158 F), mg/sq in.	6–15
Electric Properties at 255 F:	
Resistivity (d.c.), ohm-cm	2.3 x 10^{11}
Specific Inductive Capacity (1000 cps)	5.3
Power Factor (1000 cps)	3.6
Dielectric Strength (0.075-in. sheet), v/mil	450

[a]Obtained on mill-mixed Hypalon vulcanized into sheets 0.075 in. thick.
[b]Short time test, ASTM D 149-44.



***Time-temperature** limitations of Hypalon: the continuous exposure time at various temperatures that results in reduction of ultimate elongation to 100%.*

ets attached with monel bolts. Belts made of other types of rubber failed due to embrittlement and cracking of the rubber adjacent to each bucket.

Other properties — Tensile strength of Hypalon ranges from 500 to 3000 psi, depending on formulation, and hardness ranges from 55 to 95 Shore A durometer. In resilience the rubber compares favorably with other synthetic elastomers, though it generally has lower resilience than natural rubber compositions. Compression set of standard formulations is slightly higher than that of other elastomers, though lower values can be obtained when desired. Flex and abrasion resistance are very good, and the material will not support combustion.

As for electrical properties, the material has a dielectric strength ranging from 400 to 600 v/mil, resistivity of 1 x 10^{14} ohm-cm, dielectric constant at 1000 cps of 5 to 7, and power factor at 1000 cps of 2 to 3%. Electrical properties of a typical formulation are shown in Table 2.

Hypalon compositions retain their flexibility in the range of —30 to —40 F, though formulations have been compounded to resist embrittlement at temperatures as low as —80 F. Uncompounded Hypalon has a thermal conductivity (k) factor of 0.78 Btu/hr/sq ft/°F/in. Values for finished products vary with the compounding ingredients used.

The elastomer can be compounded in white or in an unlimited range of bright or pastel colors that remain stable under sunlight exposure. Colored compositions can be obtained without appreciable sacrifice of other desirable properties.

2. For coatings

The combination of properties peculiar to Hypalon can be applied to other materials by means of Hypalon coatings. The elastomer, which is soluble in many types of organic solvents, can be applied by all commercial methods, such as dipping, spraying, brushing and spread coating. Initial tests indicate that Hypalon paints can also be transfer printed on rubber from a plastic film or tape by means of heat and pressure. Coatings can be compounded for air cure at normal temperatures, or rapid cure at elevated temperatures (see Table 3). They can also be formulated to improve certain specific properties, such as temperature resistance (see Table 4). Hypalon's colorability provides many interesting possibilities in

TABLE 3—EFFECT OF CURE ON FILM PROPERTIES

Cure Temperature, F	75	212		250		275	
Length of Cure, min[a]	7 days	15	30	15	30	5	10
Mod at 300% Elong, psi	835	955	1010	1050	1160	940	1060
Breaking Str, psi	1550	1910	2015	2010	2010	2000	2010
Elong at Break, %	560	545	515	500	465	550	495

[a]Note that room temperature cure is given in days.

TABLE 4—PROPERTIES OF TYPICAL HEAT RESISTANT HYPALON COATING

AFTER CURING 30 MIN AT 302 F:	
Mod at 300% Elong, psi	1230
Breaking Str, psi	1910
Elong at Break, %	555
AFTER AGING 28 DAYS AT 250 F:	
Mod at 200% Elong, psi	2010
Breaking Str, psi	2240
Elong at Break, %	235

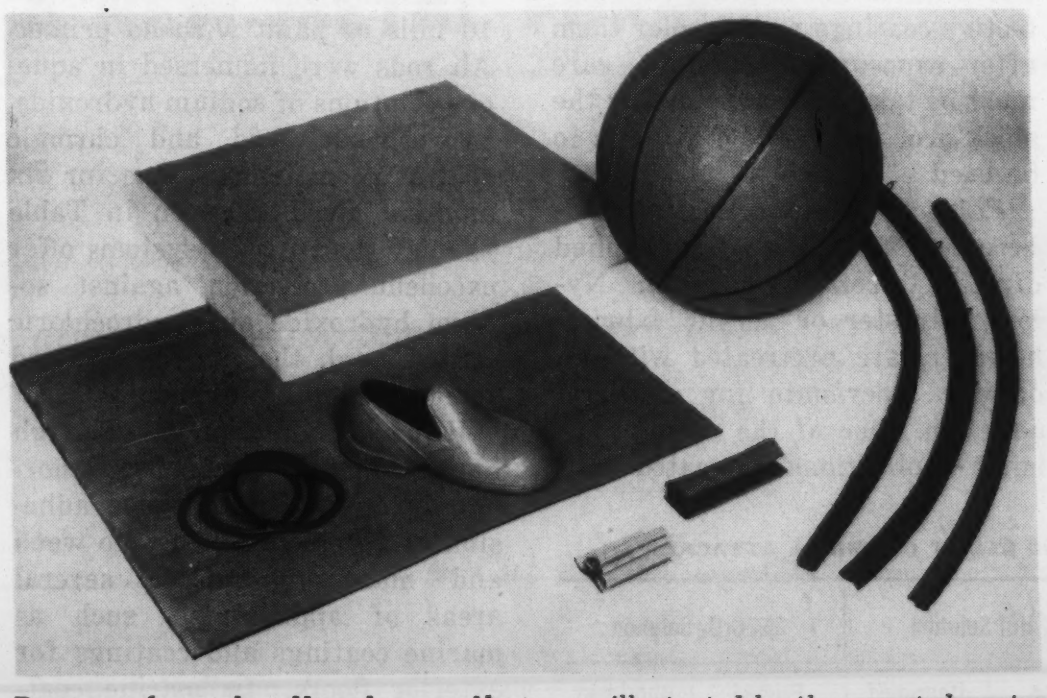
combining, in the same coating, decoration and protection.

Textured finishes can be obtained by spraying paints containing cotton or rayon flock. Coatings containing 30 parts flock per 100 parts Hypalon have been sprayed using conventional equipment.

In coatings, as in molded and extruded parts, Hypalon can be blended with various polymers to obtain a blend of properties. Hypalon can be used to add flexibility to a hard resin film such as alkyd, or conversely, a resin can be used to increase the hardness of the synthetic rubber coating. Resins that provide increased hardness are styrene-butadiene copolymers, ureas, melamines, and phenolics. In the case of urea and melamine resins, Hypalon acts as an effective polymeric plasticizer for the essentially brittle films.

Resins can also be added to improve adhesion of the synthetic rubber film to various substrates, to reduce drying time, or to help produce a tack-free surface. Table 5 compares properties of films formed from three such blends. Chlorinated rubber and some types of phenolics are used to improve adhesion to substrates such as metals and elastomers. Epoxies or polyethylenes are used to speed drying of the film to a tack-free state. Maximum resistance to blocking is obtainable with a blend of polyethylene and epoxy resins. Blends of polyethylene and chlorinated rubber also provide good blocking resistance. Other resins such as coumarone-indene, rosin esters, polyisobutylene and petroleum resins can be blended with Hypalon to improve adhesion of the coating to various substrates and to increase surface tack of adhesion formulations.

Hypalon coatings can be formulated for good dielectric properties, or for relatively good conductance characteristics. Retention of dielectric properties at temperatures up to 255 F makes the material particularly well suited for elevated temperature insulation. On the other hand, where static build-up is undesirable, coatings can be formulated with leafing aluminum powder to provide conductances ranging from 10^{-1} to



Reasons for using Hypalon coatings *are illustrated by these coated parts:* **1**—*Corrugated rubber standing mat, coated for color retention and abrasion and aging resistance.* **2**—*Electrical wire, coated for resistance to ozone cracking, and color coding.* **3**—*Child's rubber, coated for decoration and abrasion resistance.* **4**—*Rubber extrusions for car window, door and trunk weather stripping, coated for decoration and weather resistance.* **5**—*Urethane foam, coated for decoration.* **6**—*Basketball, coated with clear lacquer for abrasion resistance and resistance to sunlight.*

Convertible top *made of nylon and coated with Hypalon has good weatherability and withstands flexing.*

10^{-3} megohms. Steel can be electric welded through coatings that are kept under 0.5 mil thick.

Following is a brief discussion of the use of Hypalon coatings as applied to various substrates.

Plastomers—The oldest use for Hypalon coatings is in the form of a clear lacquer to protect elastomers in such products as footballs, basketballs and radiator hose. Colored coatings have been used on rubber footwear and coiled telephone wires for handsets. Such applications make use of the good flex strength of the coating as well as its resistance to ozone and abrasion. Colorability of coatings is particularly important in telephone wires because of the growing emphasis on colored handsets.

Paints formulated with Hypalon have been successfully used for tire sidewalls. The coatings, in a variety of colors, protect the GR-S rubber used in tires, preventing small hairline cracks due to ozone attack. Such paints are made with appreciable extender content to provide clean abrasion characteristics and to preclude peeling caused by scuffing of the tire against the curb. Hypalon paints hold color much better when applied over white sidewalls since black sidewalls contain certain discoloring oils and antioxidants.

Coatings can also be used over foam rubber. Largest application to date is a black finish for car door strips. Foam ear pads for communications equipment are also being coated to improve aging characteristics and grease resistance. Coatings may be flocked or sueded if desired.

Since most elastomers contain antioxidants, extenders and plasticers which can migrate into protective coatings and discolor them after exposure to sunlight, care must be taken in compounding the stock over which the coating is to be used.

Fabrics—Hypalon coatings adhere satisfactorily when applied directly to cotton and rayon. Nylon, polyester or acrylic fabrics, however, are pretreated with an organic isocyanate for optimum adhesion. One of the most promising applications of coated fabrics is convertible car tops. Such treated tops weather well, resist soiling, have good flex life and offer interesting possibilities in color variety. Coated fabric has also been used successfully in camera bellows and tarpaulins.

Though Hypalon contains chlorine, it does not attack fabrics when properly compounded. Formulations can be altered to provide specific improvements in resistance to weathering, chemicals or water. A 5-mil coating is adequate for most applications.

Metals. Protective coatings formulated for chemical stability can be used as linings for tanks and fume ducts and for similar applications. Primers are recommended for maximum adhesion. Adhesion of 5-mil films to sandblasted steel, as measured by peeling, is 8-10 lb. per in. of width without a primer, but is greater than 25 lb. per in. with a primer. For a comparison of scratch adherence of Hypalon coating with other types see Table 6 on this page.

Effectiveness of the protection offered by such coatings has been measured on high carbon steel rods. Three rods were coated with 3 mils of primer and 10 mils of an air-curing Hypalon paint. Three other rods were coated with 10 mils of paint with no primer. All rods were immersed in aqueous solutions of sodium hydroxide, hydrochloric acid and chromic acid at room temperature for six months. Results, given in Table 7, show that primed systems offer excellent protection against sodium hydroxide and hydrochloric acid, though the film is softened somewhat in chromic acid.

Wood and masonry — Though applications have not been thoroughly evaluated, the good adhesion of Hypalon coatings to wood and masonry indicate several areas of applications, such as marine coatings and coatings for exterior floors. In marine coatings it can be used both as a weather resistant paint above the water line and as an anti-fouling paint below the waterline. In one decking application, a coating has remained in good condition during more than three years of use.

TABLE 5—PROPERTIES OF COATING BLENDS[a]

STYRENE-BUTADIENE-HYPALON	
Mod at 300% Elong, psi	1985
Breaking Str, psi	2760
Elong at Break, %	365
Taber Abrasion, gm loss/1000 rev	0.25
CHLORINATED RUBBER-HYPALON	
Mod at 300% Elong, psi	2050
Breaking Str, %	2235
Elong at Break, %	325
Taber Abrasion, gm loss per 1000 rev	0.24
EPOXY-HYPALON	
Mod at 200% Elong, psi	1565
Breaking Str, psi	1760
Elong at Break, %	265
Taber Abrasion, gm loss/1000 rev	0.22

[a]Cure cycle for all coatings: 30 min at 302 F.

TABLE 6—COMPARATIVE SCRATCH ADHESION[a]

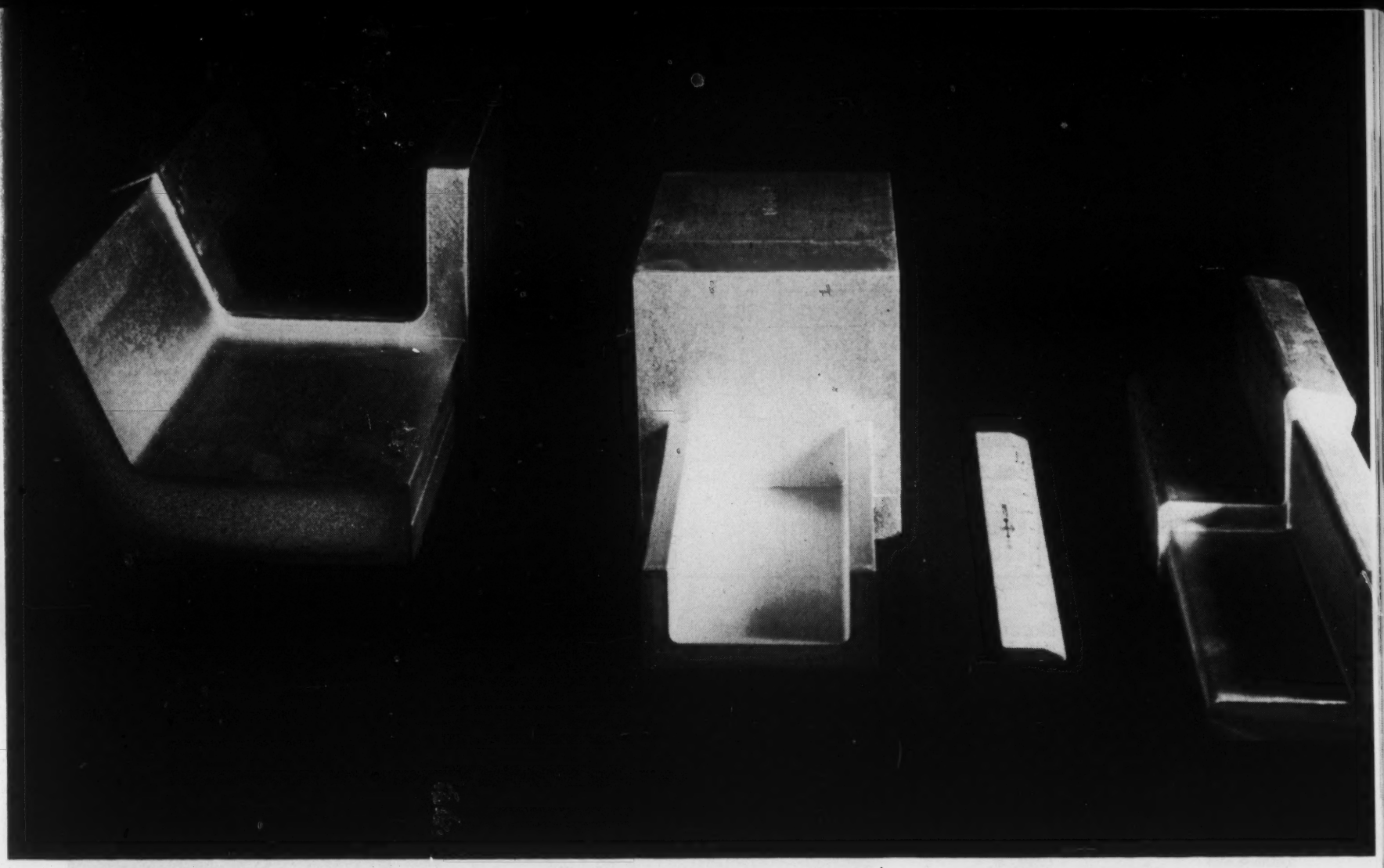
Coating on Steel Plate (2 mils total coat thk)	Scratch Adhesion, gm to failure
Primed Hypalon Coating	4000
Nitrocellulose-Based Refrigerator Enamel	3150
Alkyd-Based Refrigerator Enamel	2550

[a]As measured by Hoffman Tester.

TABLE 7—HOW COATED STEEL RODS RESIST CHEMICAL ATTACK[a]

	5% NaOH Solution		2% HCl Solution		2% CrO_3 Solution	
	Primed Coating	Unprimed Coating	Primed Coating	Unprimed Coating	Primed Coating	Unprimed Coating
Hypalon Paint Films	Excellent	Good, some blisters	Excellent	Excellent	Surface softened	Surface softened
Steel Rods	Excellent, no corrosion	Slight corrosion	Excellent, no corrosion	Slight corrosion	Excellent, no corrosion	Slight corrosion

[a]Immersion for 6 mo at room temperature.



***Typical** stepped extrusions.*

Stepped Extrusions

A NEW METAL FORM

It is now possible to obtain an aluminum extrusion having two or more different cross sections. Such extrusions can be used to:

- *Simplify design*
- *Reduce machining*
- *Cut materials cost*

by C. J. Hoffman, *Kaiser Aluminum & Chemical Corp.*

■ The stepped extrusion, by placing material where it is required along the extruded length, makes it possible to design integral connecting lugs and thereby obtain longer extruded structural members. It also reduces both machining requirements and raw materials cost. Stepped extrusions are currently used in aircraft spar cap applications.

Stepped extrusions are commonly produced by utilizing two sets of extrusion dies. The small or "minor" section is extruded first to the desired length, at which point the extrusion cycle is interrupted long enough to change dies. The large or "major" configuration is then extruded. (In most cases the dies consist of two segments to facilitate removal from the extruded part. Schematic tooling arrangements are illustrated elsewhere in the article.)

Design

Although the major and minor sections may frequently have a common plane, this is not a requirement of the process. In all cases, however, the major section must completely enclose the minor section. It is generally necessary to provide machining stock on all

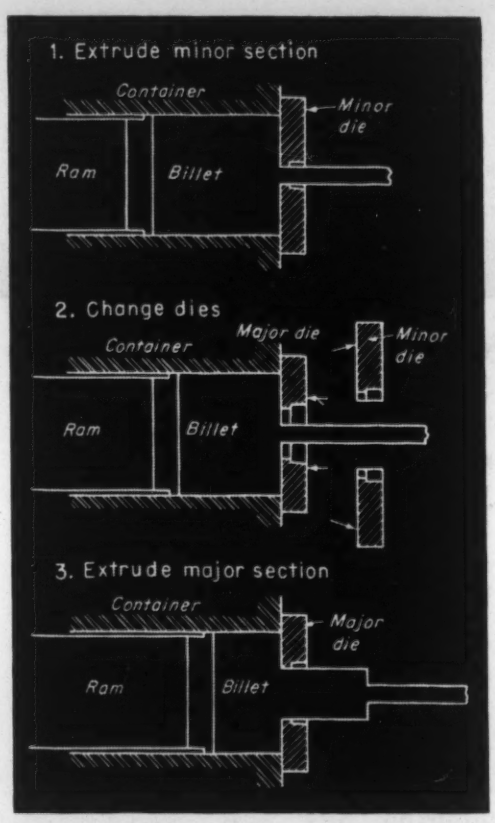
MECHANICAL PROPERTIES OF 7075-T6 STEPPED EXTRUSIONS

Major Section						Junction			Minor Section					
Thk, in.	Area, sq in.	Test Dir	Ten Str, 1000 psi	Yld Str, 1000 psi	Elong, %	Ten Str, 1000 psi	Yld Str, 1000 psi	Elong, %	Thk, in.	Area, sq in.	Test Dir	Ten Str, 1000 psi	Yld Str, 1000 psi	Elong, %
1.70	8.69	Long.	89.4	83.2	8.8	89.9	81.6	9.0	0.68	4.42	Long.	90.3	84.2	9.1
3.06	16.05	Long.	89.4	82.1	8.0	—	—	—	0.72	5.98	Long.	90.2	84.8	10.0
2.23	17.29	Long.	86.7	81.9	8.9	87.3	80.3	6.8	1.10	5.36	Long.	87.0	79.9	10.1
1.98	21.28	Long.	88.8	81.2	10.2	88.0	78.8	9.5	1.58	12.11	Long.	91.6	83.4	9.2
		Trans	80.1	71.7	6.8	—	—	—	—	—	Trans	84.7	72.5	9.8
4.66	28.95	Long.	86.8	81.2	11.0	—	—	—	1.40	10.63	Long.	91.0	84.4	9.0
		Trans	71.2	60.8	4.6	—	—	—	—	—	—	—	—	—
5.32	29.32	Long.	88.2	75.8	9.5	79.5	71.9	4.0	0.485	3.30	Long.	90.4	84.3	12.0
		Trans	71.0	58.8	4.7	—	—	—	—	—	Trans	77.6	72.4	4.0

SPECIFICATION MINIMUM VALUES[a]

Thickness, in.	Area, sq in.	Ten Str, 1000 psi	Yld Str, 1000 psi	Elong, %
Through 0.249	All	78.0	70.0	7.0
0.250–2.999	All	80.0	72.0	7.0
3.000–4.499	Through 20	80.0	70.0	7.0
3.000–4.499	Over 20, through 32	78.0	70.0	6.0
4.500–5.000	Through 32	78.0	68.0	6.0

[a]All properties measured in longitudinal direction.



***How** a stepped extrusion is produced.*

surfaces to obtain the required dimensional accuracy and surface finish.

In designing a stepped extrusion it is important to use dimensional tolerances that are realistic, yet avoid an excess of stock. Stepped extrusion tolerances have not been standardized, but those given in the accompanying sketches are typical. Straightness tolerances differ from those for normal extrusions. In addition, special tolerances apply to the step area and across the parting line when split dies are used.

Straightness of the over-all part is measured by deviation from a reference line, the junction or step area (8 in. on either side of the step) being excluded. Straightness of the minor or major portion of the extrusion is determined individually. Because of the difference in flow conditions in extruding the major and minor sections, the junction area usually presents the greatest straightening problems. Minor and major portions are usually furnished to standard extrusion straightness tolerances.

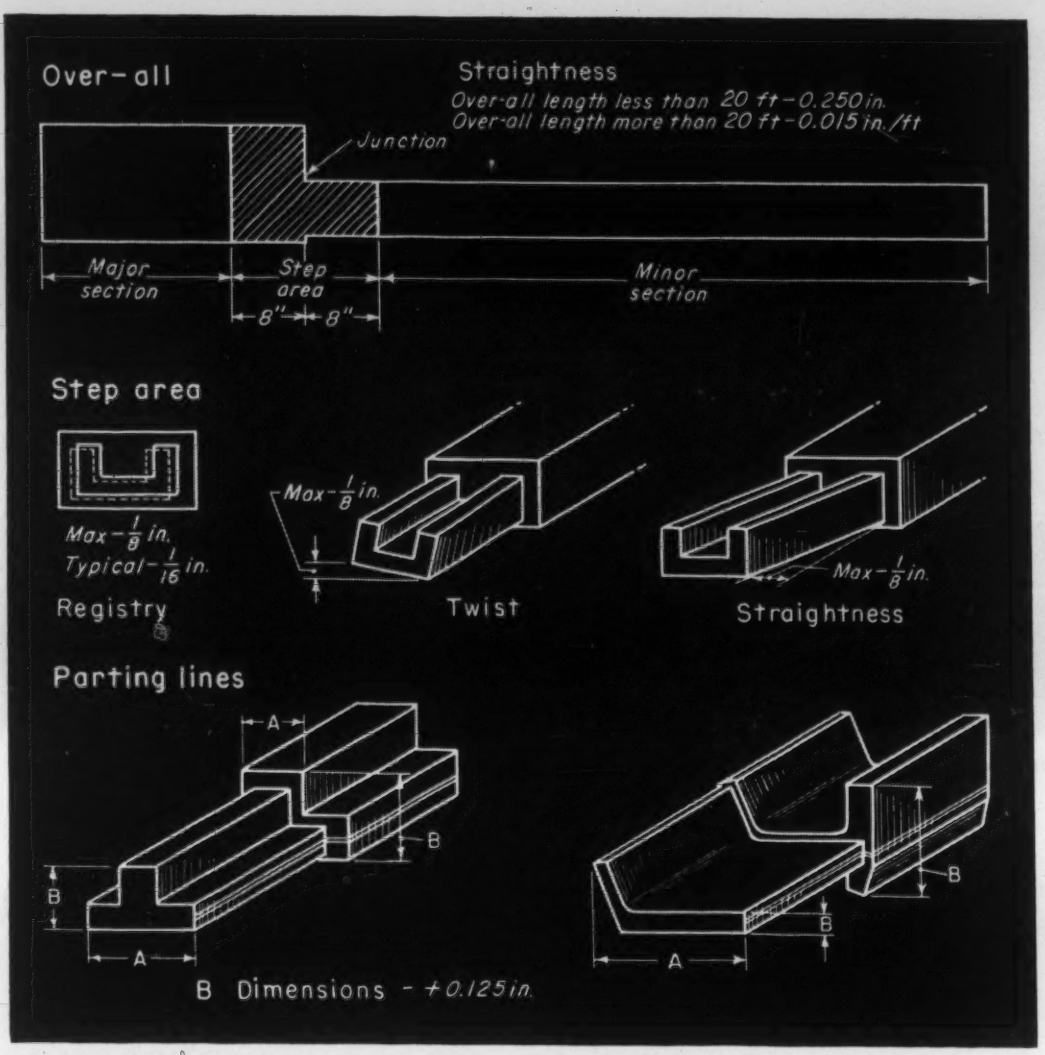
Because of the inherent instability of split dies, cross sectional tolerances of stepped extrusions are usually greater than for normal extrusions. In locating parting lines it is important to consider not only tolerances but also the ability to remove tools from the section. It is sometimes necessary to provide slight draft angles on extended elements.

Mechanical properties

The cross-sectional areas of major and minor sections and the ratio of major to minor area have a marked influence on the mechanical properties obtainable. In normal aluminum extrusions, mechanical properties are dependent on the degree of working as measured by the reduction ratio, i.e. the ratio of extrusion press container area to the area of the part being extruded. For example, substandard mechanical properties are obtained in 7075 aluminum alloy with reduction ratios less than about 6:1, and reduction ratios greater than about 30:1 require excessive pressures. In stepped extrusions, the major to minor area ratio should not exceed 5:1 if the section is to be produced under optimum conditions.

The mechanical properties of stepped extrusions, particularly in the junction area, have been the subject of many discussions, but no agreement has been reached. Because of differences in areas and thicknesses it may be necessary to work to two sets of allowable design stresses in the major and minor portions.

From the standpoint of pressure requirements the major sec-

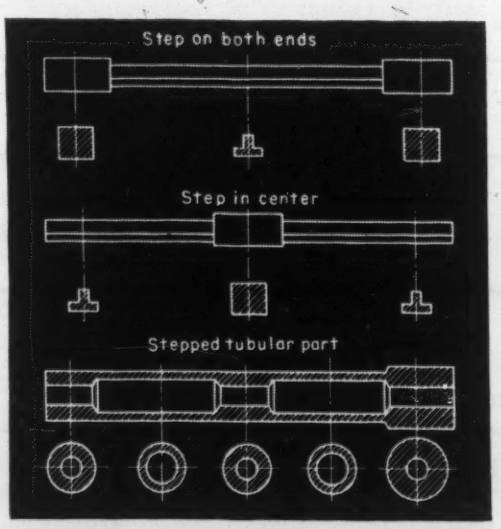


***Tolerances** typically achieved in stepped extrusions.*

tion has the advantages of a lower reduction ratio and the reduced billet length resulting from extrusion of the minor section. However, the lower reduction ratio also affects mechanical properties. Properties of typical 7075-T6 aluminum alloy stepped extrusions are given in the table. In most cases the strength levels in the minor section are slightly greater than in the major, with the junction properties being equal to or slightly lower than those in the major section. The effect of higher-than-recommended major-to-minor area ratios is shown by the properties given for the last extrusion in the table where the ratio is 8.9 to 1. Strength levels in the major section are considerably below those of the minor section in both longitudinal and transverse directions, and the junction properties fall below those of the major section.

Finishing

Finishing operations for stepped extrusions follow, in general, the practices used for normal products. A typical sequence



***Future** stepped extrusions now visualized by aircraft designers.*

of operations for 7075 aluminum alloy stepped extrusions is: 1) extrude, 2) solution heat treat, 3) stretch straighten, 4) cut to length, and 5) age.

Time at temperature in solution heat treating stepped extrusions is determined by the thickest element of the major section. In stretching operations normal practice is to grip each end of the section in a hydraulic unit and exert the necessary stretching force to straighten the part. In a stepped extrusion, because of differences in area, all of the permanent set occurs in the minor section. If straightening operations are necessary on the major section and step area, a gag press may be required. Straightening is performed before solution heat treatment wherever possible to avoid leaving residual stresses.

All stepped extrusions are machined to varying degrees, and warpage following machining is frequently aggravated by differential residual stress patterns in the minor and major sections of the extrusion. Experience on plate indicates that stretching to a 2% permanent set will virtually eliminate warpage following machining operations. Similar results can be achieved by stretching extrusions, although the optimum amount of stretching required has not been clearly established.

Future developments

Extrusion technology has advanced rapidly in the past few years and it is difficult to predict lines of future growth. Products that a few years ago were considered impossible or impractical to form are now in production. An extrusion with a major section on both ends is a possibility. This would allow an integral fitting to be used on both extremities of an extruded part.

Stepped extrusions with the major portion located in the center of the part are also possibilities. Extrusions of this type could be used for aircraft stabilizer spar caps extending completely through the fuselage or for similar applications on the wing. In some cases the enlarged center portion could be used for attachment points for the landing gear.

It may also be possible to produce parts with two, three or more steps. Three or more sets of dies would be used to produce the desired configurations. The additional operations together with increased tooling costs would add to the cost of the section, of course. Economically it has been difficult to justify additional steps in most cases.

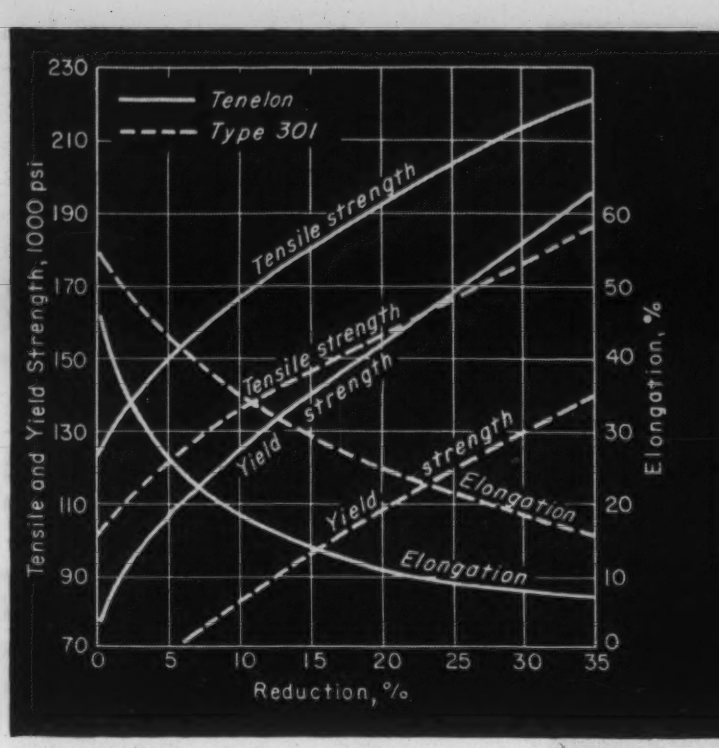


Fig 1—*Effect of cold rolling on the mechanical properties of Tenelon and type 301.*

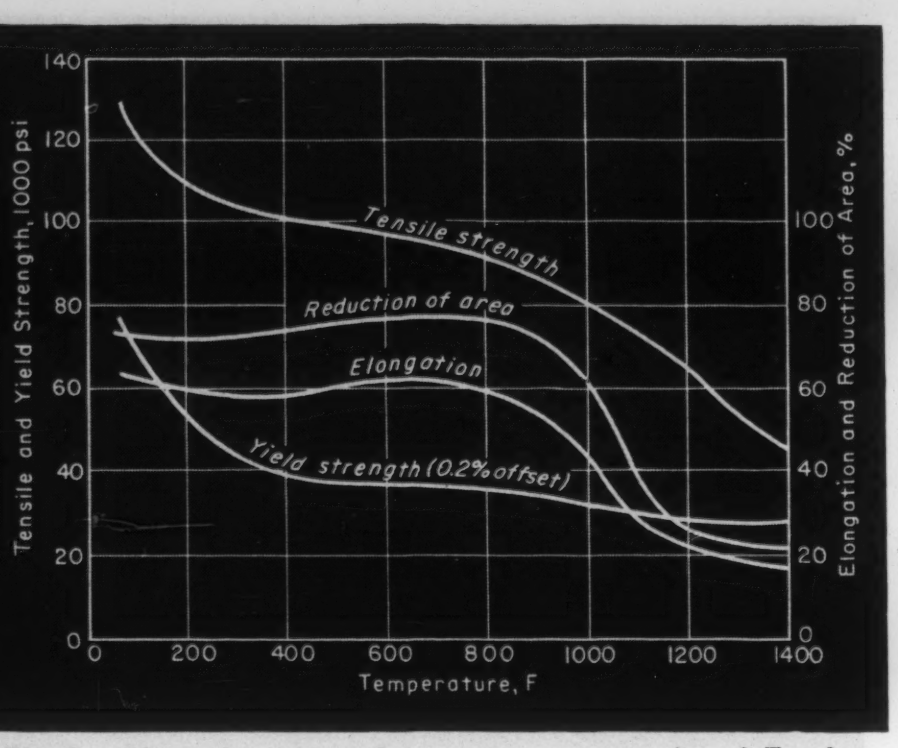


Fig 2—*Short time elevated temperature properties of Tenelon.*

Here are the properties of a

Nickel-Free

Chromium-manganese-nitrogen grade looks promising as a replacement for the 18-8 nickel-containing grades.

TABLE 1—MECHANICAL PROPERTIES OF ANNEALED FLAT ROLLED MATERIAL

Material	Yield Strength (0.2% offset), 1000 psi	Tensile Strength, 1000 psi	Elongation (in 2 in.), %
Tenelon	70	125	45
Type 302	40	90	50
Type 301	40	110	60

TABLE 2—COMPARATIVE STRESS RUPTURE PROPERTIES

Material	Stress, 1000 psi, for Rupture in 1000 hr at			
	900 F	1050 F	1200 F	1350 F
Tenelon	68	41	28	12
Types 302, 304	49	32	17	8
Type 347	56	43	23	11
Type 316	—	44	24	12

TABLE 3—COMPARATIVE CORROSION RESISTANCE
Mils Penetration per Month after 96-Hr Exposure

Environment	Tenelon	Type 301	Type 302	Type 201	Type 430	16-1-17
5% Lactic Acid (86 F)	0.01	0.01	0.01	0.01	0.01	0.01
10% Phosphoric Acid (86 F)	0.01	0.01	0.01	0.01	0.01	0.01
60% Acetic Acid (158 F)	0.01	0.01	0.01	0.01	0.017	0.01
5% Sulfuric Acid (86 F)	390	1.0	1.0	13.0	390	200
5% Nitric Acid (boiling)	0.07	0.030	0.030	0.030	0.13	0.07

■ A new nickel-free austenitic stainless steel containing chromium, manganese and nitrogen has been developed by United States Steel Corp. to conserve the critical nickel supply. Called Tenelon, this chromium-manganese nickel steel has excellent tensile properties at room and elevated temperatures. Its resistance to the atmosphere and to mild acids is comparable with that of Types 301 and 302 chromium-nickel grades.

Although the new steel is in commercial production, applications are in the development stage and fields of use are still being investigated. It is currently being tested in rail cars, trailers, liquid fertilizer tanks, pots and pans, and various defense applications.

Nominal composition of the steel is 17 chromium, 14.5 manganese and 0.40% nitrogen. In addition it contains a maximum of

***Trailer bodies** are among the potential applications of this new steel.*

Austenitic Stainless Steel

0.10 carbon, 1.0 silicon, 0.045 sulfur and 0.045% phosphorus. The combination of manganese and nitrogen yields an austenitic structure over a wide temperature range and assures good hot workability. Corrosion resistance is promoted by maintaining the chromium at 17% and restricting the carbon content.

Mechanical properties

Tensile properties of the new chromium-manganese-nickel steel are compared with those of typical 18-8 chromium-nickel steels in Table 1 and Fig 1. In the annealed condition, the new steel has higher tensile and yield strengths than 18-8 and the elongation is only slightly lower. Effect of cold rolling on strip is shown in Fig 2. At 35% reduction, for example, tensile strength of the new steel is 220,000 psi, yield strength 185,000 psi and elongation 8%. Corresponding figures for Type 301 are 192,000 psi, 140,000 psi and 15%.

Short time elevated temperature tensile properties of Tenelon are said to be approximately equal to those of 18-8 Mo and somewhat higher than those of the standard 18-8 grades. In 1000-hr stress rupture tests similar results are obtained (see Table 2).

Corrosion resistance

Examination of samples of the new stainless after 1-yr exposure to rural, industrial and marine atmospheres indicates that the resistance of the steel is comparable with that of Type 302 in these environments.

Laboratory tests in acid solutions on a series of stainless steels show that Tenelon resists mild acids as well as chromium-nickel Types 301 and 302, chromium-nickel-manganese Type 201 and chromium Type 430. In strong acids, however, the nickel-free material is inferior to the nickel-bearing grades, but it is equal to the straight chromium Type 430. Corrosion rates are given in Table 3.

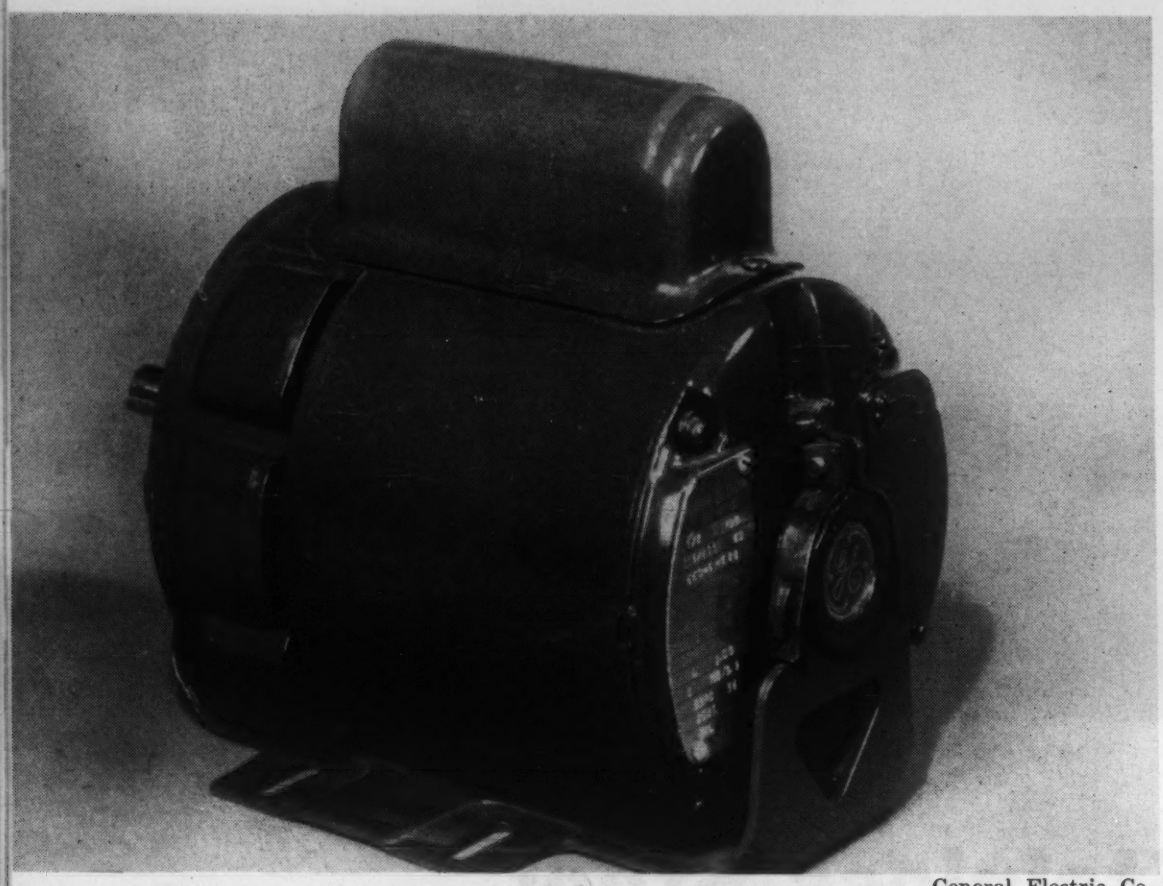
Welding

Sheet material up to ⅛ in. thick can be joined readily by the shielded metal arc process. Use of covered chromium-nickel electrodes, designated as E308 and E312 in ASTM's Specification A298-55T, is recommended.

Spot welding of 0.048-in.-thick Tenelon sheet shows that optimum weld properties are obtained with 1½ times the force and twice the time required in welding 18-8 of the same thickness. Tests of these spot welds indicate greater strength and ductility than are obtained with 18-8.

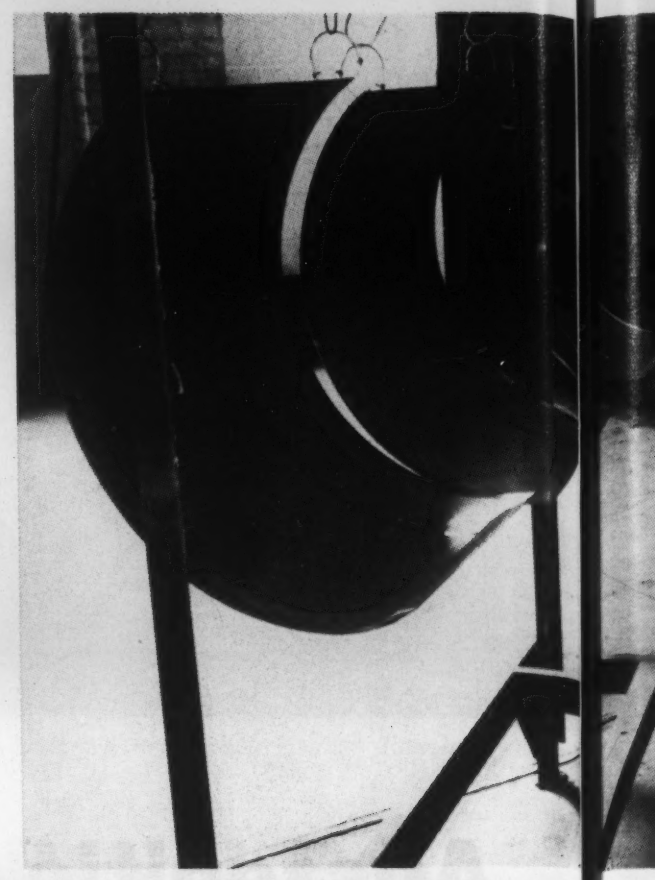
NOMINAL COMPOSITIONS (%) OF STEELS MENTIONED

Steel	Chromium	Nickel	Manganese	Carbon	Other
Tenelon	17	—	14.5	0.10 max	0.40 N
301	17	7	—	0.08-0.20	—
302	18	9	—	0.08-0.20	—
347	18	10.5	—	0.08 max	10xC min Cb
316	17	12	—	0.10 max	2.5 Mo
430	16	—	—	0.12 max	—
201	17	4.5	8.5	0.15 max	—
16-1-17	16	1	17	0.12 max	0.15 N



General Electric Co.

Motor *is protected against water, solvents and oils by* **phenolic** *primer.*



Perforated screens *use phenolics*

Phenolic Coatings

Coatings based on phenolic resins are noted for their excellent resistance to chemicals, solvents, oil and water, together with high abrasion and mar resistance. Here is an informative guide to the properties, uses and cost of these popular coatings.

by R. B. Young, *General Electric Co.*

■ Coatings based on phenolic resins—among the oldest of the synthetic resins—are widely used for the protection of metal parts and products. Applications include bright brass coatings; linings for cans and drums, storage tanks, tank cars and processing equipment; and primers for many products where a high degree of chemical or solvent resistance is required.

The four principal types of phenolic coatings are:

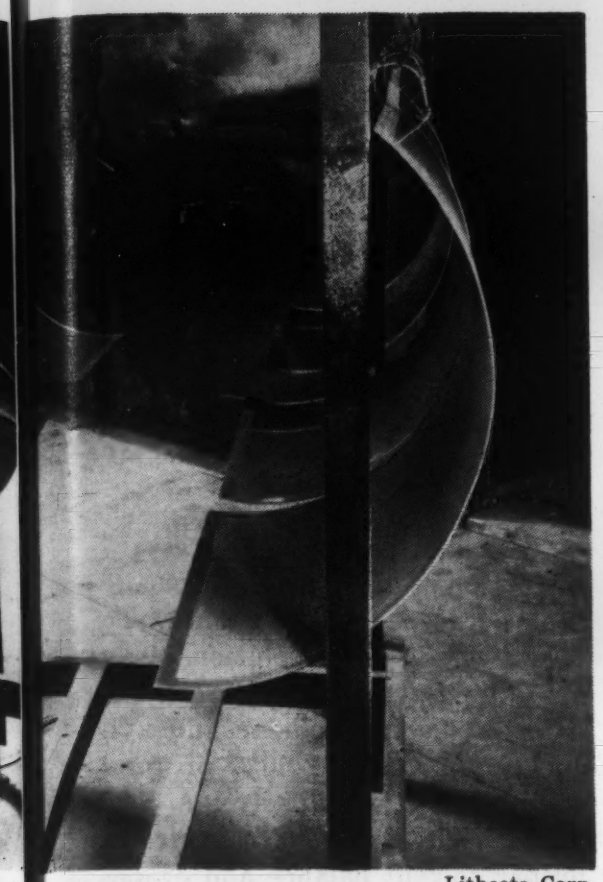
1. *Straight (100%) phenolics.* These are the most widely used type.

2. *Substituted or polyhydroxy phenolics,* such as cresol and resorcinol resins. These may be used alone or as modifiers to augment specific properties such as hardness or baking speed.

3. *Blocked phenolics.* The blocked phenolics are relatively new and are gaining increased acceptance because of their unique properties. This class of phenolics has all of the chemical resistance properties of the regular phenolics plus resistance to strong alkali solutions, soap and detergent solutions, and strong oxidizing media. They are also more compatible with the epoxy, vinyl and alkyd resins than are most of the other phenolic resins.

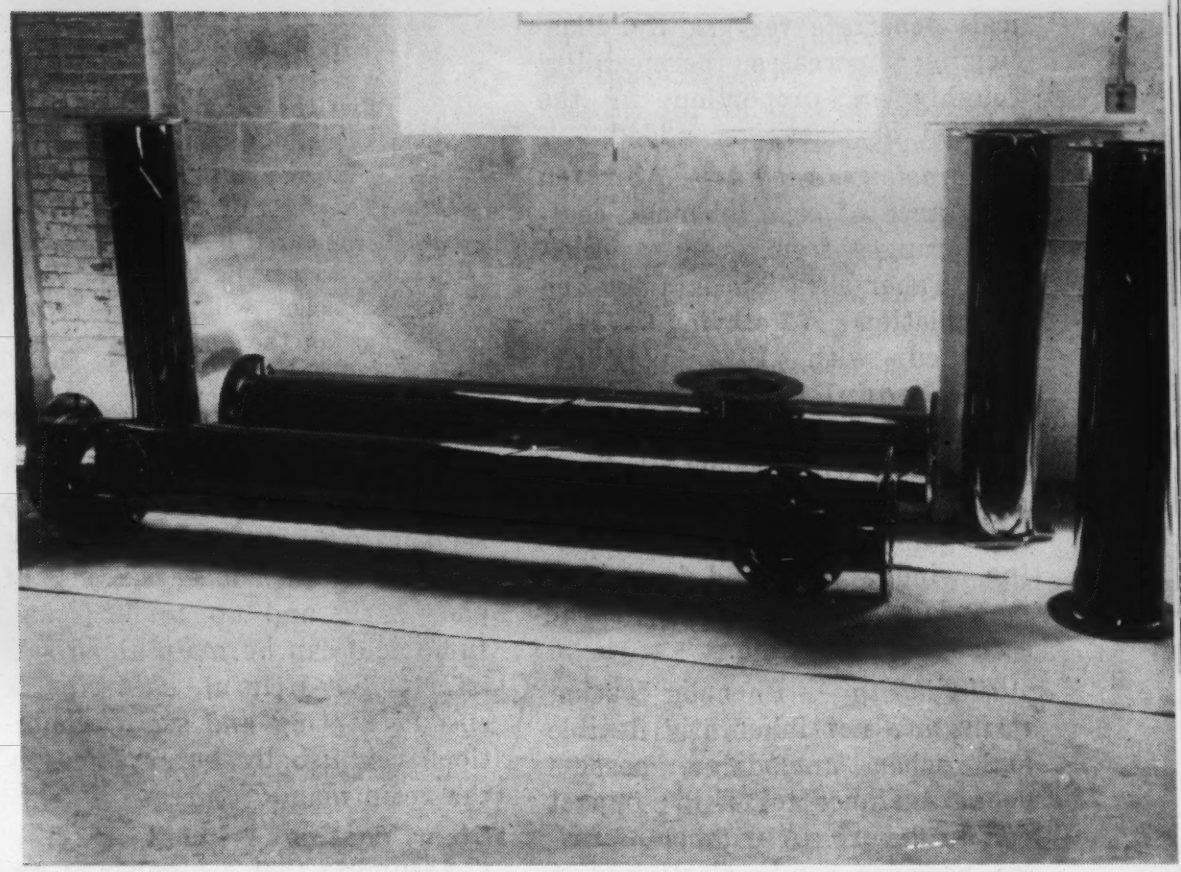
4. *Phenolic oil varnishes.* Phenolic oil varnishes are widely used as can linings and primer vehicles for metal products, chiefly because of their fast drying time, toughness, flexibility and water resistance. (These varnishes are also quite popular for wood finishing.) Resistance to oil and solvents is considerably less than that of the other types.

Fully cured phenolic coating resins tend to be brittle, although there is some variation between different resins, generally in the substituted types. With one exception, resins in the first three



Lithcote Corp.

to resist corrosion and abrasion.



Lithcote Corp.

***Spiral welded headers** have phenolic coating on both interior and exterior for resistance to solvents, oils and aqueous solutions.*

for Metal Products

classes listed above must be plasticized or modified with another resin for applications requiring an extreme degree of flexibility. Epoxy, polyvinyl butyral and polyvinyl formal resins are widely used for this purpose. In general, 50 to 75% of epoxy resin or 10 to 40% of polyvinyl butyral or formal resins are used.

Clear coatings — properties

Adhesion—The adhesion of clear phenolic films is good on iron, steel (except highly polished steel), brass and copper, and fairly good on aluminum, magnesium, zinc and cadmium. Adhesion is also good on wood, glass, fabric, ceramics and many plastics. The coatings adhere much better to roughened surfaces such as those obtained by sand blasting, acid etching, and phosphate and chromate treatments. Surface roughness, however, should not be too extreme, as thin spots in the coating produced by sharp or jagged peaks can cause premature failure.

Appearance—Clear baked phenolic coatings have a smooth, glossy appearance and a pleasing pale to deep golden color. In addition to being decorative, this golden color helps to hide defects on metal surfaces. With the exception of the varnishes, phenolic coatings dull quickly during outdoor exposure; however, the integrity of the coatings and their protective value is good over long time periods. Coatings exposed for as long as 3 yr in humidity rooms and protected from ultraviolet light have shown little or no loss of gloss.

Porosity—Due to their highly crosslinked structure, phenolic resins form the most dense and least permeable protective coatings available for metals. Moisture permeability is extremely low and corrosive ions from chem-

Baked Phenolic Coatings Resist . . .

Mineral acids
- Hydrochloric (to 20%)
- Sulphuric (to 75%)
- Phosphoric (to 85%)
- Nitric (to 10%)

Chemicals and solvents
- Alcohols
- Ketones
- Esters
- Ethylene glycol
- Hydrogen peroxide
- Acetaldehyde
- Penetrating oil
- Transil oils

Organic acids
- Acetic
- Oleic
- Citric (to 60%)
- Propionic
- Formic (to 60%)

Other substances
- Lacquer solutions
- Turpentine
- Casein paint
- Oil varnishes
- Beer
- Cola concentrates
- Lard

icals penetrate very slowly. Plasticizing increases permeability roughly in proportion to the amount of plasticizer added.

Abrasion resistance—Abrasion resistance of clear phenolic coatings ranges from good to excellent. Taber abrasion data for one formulation (Methylon 75108 modified with 10% polyvinyl butyral resin) have shown a tenfold increase in abrasion resistance over a typical short oil alkyd-melamine system. The mar resistances of a blocked phenolic coating, window glass and four other materials are compared in the accompanying graph.

Flexibility — Phenolic coating resins are not inherently flexible and, when unmodified, possess poor resistance to offside impact and to flexure. A number of resins, however, can be plasticized in relatively thin films (0.1 to 0.3 mil) to withstand the severe drawing and forming encountered in the manufacture of cans. Phenolic oil varnishes, in contrast, are quite flexible and have been used in can manufacture for some time. To offset their lower water and chemical resistance, these coatings are usually used in thicknesses up to 0.5 mils.

Clear phenolic coatings are capable of withstanding exposure to dry heat up to about 700 F for short periods. Upon continued exposure to high temperatures, the films have a tendency to darken and become brittle. Low temperatures have very little effect on the coatings other than to reduce flexibility.

Chemical resistance—The outstanding feature of phenolic coatings is their chemical resistance. They are unaffected by most solvents and possess high resistance to mineral and organic acids and aqueous solutions. Only the blocked phenolics have really good resistance to alkalies, soap solutions and oxidizing media such as chromic acid.

Although their resistance to mineral acids is very good, few of the phenolic coatings are recommended for service with hydrochloric or nitric acids whose concentration is greater than 20%. This is especially true if elevated temperatures are involved. Contact with all concentrations of phosphoric and up to 50% sulfuric acid can be maintained satisfactorily. Helpful data for a specific coating and set of conditions can usually be supplied by the resin manufacturer.

One of a Series

This is the second in a series of articles on synthetic resin-base coatings for metal products. The first of these articles, which appeared last month, was devoted to acrylic coatings. Future articles will cover such coatings as the epoxies, the vinyls and the silicones.

Clear coatings — cost

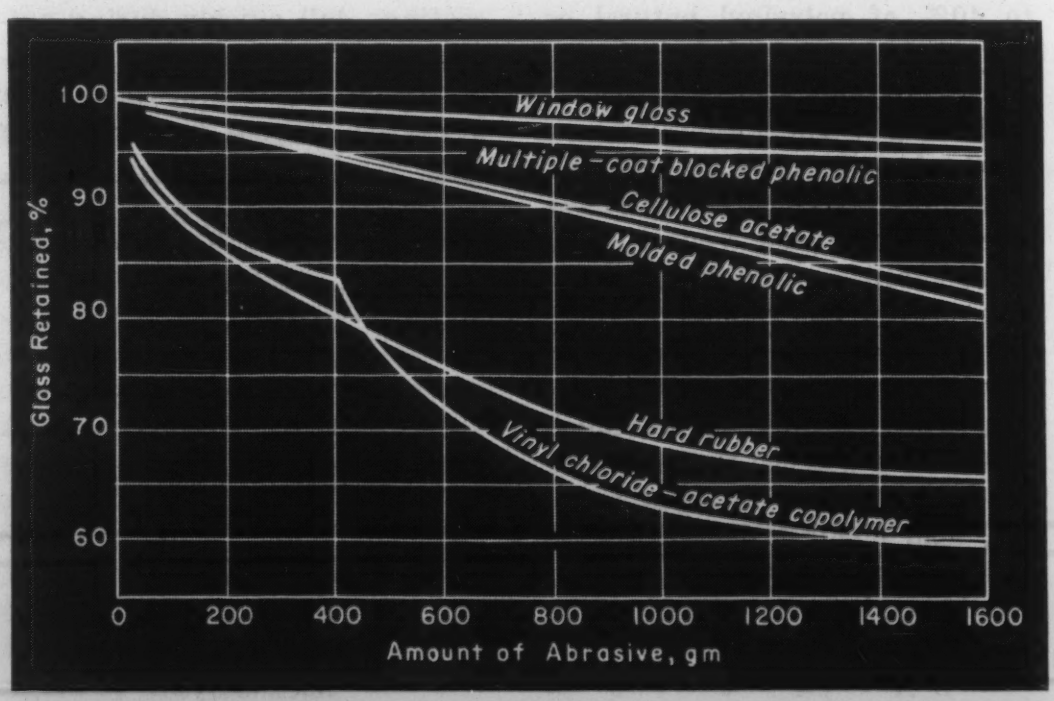
Assuming that a number of organic coatings possess the required properties for a specific application, consideration must be given to such factors as the following before an objective cost comparison can be made: 1) density of film and thickness required, 2) percentage of solids at application viscosity, 3) cost of resin on a 100% solids basis, 4) coverage in square feet or in number of parts per gallon, and 5) cost of the solvent system.

On a 100% solids basis, phenolic coating resins cost from 35 to 80¢ per lb, the average being about 45 to 60¢ per lb. Based on an average specific gravity of 1.25 gm per cu cm for baked phenolic coatings, the maximum coverage is about 350 sq ft per gal per mil for a 30% solids resin solution. The materials cost per 1000 sq ft per mil dry is $5.55, assuming 55¢ per lb for 100% resin solids, 7¢ per lb for solvents, 30% resin solids at application viscosity, and 100% efficiency.

Polar solvents such as alcohols, ketones and esters are necessary to dissolve all phenolic coating resins except the varnishes. To lower costs, these solutions may be diluted with aromatic hydrocarbons such as toluene and xylene up to at least 50% of total solvent. With mixed solvents, care must be exercised to insure a proper solvent balance and evaporation rate. To avoid a small amount of resin throwout and cloudy films, the polar solvent should be the last to leave the drying film. Toluene-denatured alcohol, xylene-diacetone alcohol, and xylene-butyl alcohol are examples of workable blends.

Primers

Ordinarily, phenolic primers utilize the same resins that are used in clear coatings. For this reason, the general properties and applications of the two types of coatings are similar. Pigmented



Comparative mar resistance *(ASTM D 673-44) of a blocked phenolic coating and five other materials.*

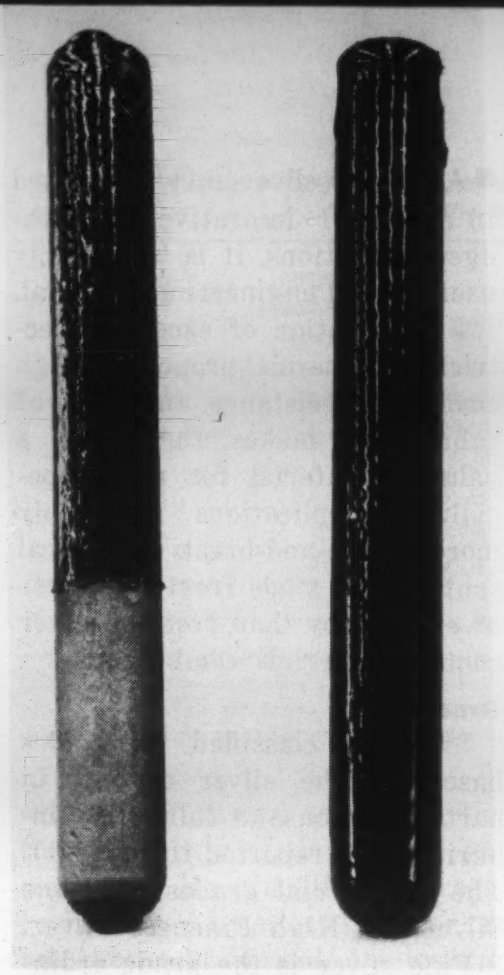
phenolic primers are used extensively in multiple coats as linings for storage cars, tank cars and processing equipment, and have been used for many years on appliances as primers under alkydamine topcoats.

Other than color, there is usually no particular problem in pigmenting phenolic resins. Some of the common primer pigments are zinc oxide, red iron oxides, zinc chromate, titanium dioxide and titanium dioxide-lithopone combinations. If an acid catalyst is used to cure the resin, use of basic pigments such as calcium carbonate or zinc oxide should be avoided. In some formulations pigment additions often produce films with improved toughness and adhesion.

All of the phenolic coating resings tend to yellow when baked and this factor should be considered when pigments are formulated for specific colors or shades. Exact duplication of shades cannot be expected as variations in bake time or temperature tend to produce slightly different degrees of yellowing. Phenolic resins are not suited for white or very light tints.

Despite the fact that highly pigmented phenolic primers tend to be more porous than clear coatings, their protection against aqueous solutions and high humidity atmospheres is at least as good as that of the clear coatings. Resistance of the pigmented primers to corrosive chemicals, however, is lower than that of equivalent clear coatings. If resistance to strong alkalies or acids is necessary, care must be taken to select pigments that are resistant to these media. An equal number of pigmented primer coats and clear topcoats are usually used when multiple coats are required. One coat systems are used in a large number of specialty applications, such as air conditioning equipment.

Except for the added factors of pigmented cost and density, the cost criteria of pigmented primers are the same as those for the clear coatings. At the optimum application viscosity a pigmented coating will be thicker than a corresponding clear coating. Based on the same average specific gravity of 1.25 gm per cu cm for the baked resin film, the maximum coverage is approximately 670 sq ft per gal per mil at 54% total solids (30% resin solids). The materials cost per 1000 sq ft per mil dry is $3.80, assuming 55¢ per lb for 100% resin solids, 7¢ per lb for solvents, 25¢ per lb for the average pigment, and 100% efficiency.



Comparison of protection *afforded by two different phenolic coatings to a 16% caustic solution at 195 F. Conventional straight phenolic coating on steel probe on left lasted 30 min, whereas blocked phenolic coating on probe on right showed no deterioration after five months.*

Phenolic-epoxy blends are especially noted for their outstanding properties and broad range of utility. These blends combine the best properties of each resin and may be used clear, as high gloss pigmented topcoats, and as pigmented primers. Depending on the properties desired, blend ratio ranges from 50 to 75% epoxy. As the amount of epoxy resin is increased, resistance of the coating to strong solvents decreases and flexibility increases. Although excellent flexibility is obtained throughout the above range, optimum resistance properties vs flexibility should be judged for each application. The Synthetasine coating for lining drums is a good example of a blocked phenolic and epoxy blend.

Applying the coatings

Phenolic resin coatings may be applied by spray, dip, roller, flow and slush coating. Although cure temperatures can vary widely most coatings are usually baked at 300 to 400 F. Some catalyzed resin solutions will cure at room temperature; however, coatings cured in this manner usually lack the chemical resistance of baked films. A minimum threshold temperature of about 325 F is required to obtain optimum film properties. Cure times of 10 to 30 min are usually sufficient. In general, cure time should not be less than 5 min or more than 60 min.

Resins requiring catalysts cure faster as catalyst concentration is increased, but the threshold temperature must still be reached to obtain the desired coating properties. Moderate overbakes cause little harm but may cause the film to darken and lose flexibility. Some typical optimum time-temperature cure relationships are listed below:

Cure Temp, F	Time, min
325	30
350	20
400	12
450	8
500	6

If multiple coats are to be applied, better adhesion can be obtained if the first coat is not fully cured. This procedure should be followed up to the final coat, which is given the full cure cycle.

The shelf stability of phenolic resin solutions varies considerably. Straight heat convertible resins tend to have the least stability, but most resin solutions can be stored for at least 3 mo at room temperature. Dilution to spray or dip viscosity markedly increases shelf life. The effect produced by blending with other resins or adding catalysts may drastically change shelf life and should be carefully checked.

P. R. Mallory & Co.

***Electrical contacts** of silver.*

For electrical and chemical equipment try . . .

Fine Silver

It has unsurpassed electrical and thermal conductivities and excellent corrosion resistance

by Edward E. Tietz,
Special Products, Handy & Harman

■ Although silver is widely used in alloys for decorative and coinage applications, it is also highly useful as an engineering material. Its combination of excellent electrical and thermal properties, high corrosion resistance and ease of fabrication makes the metal a valuable material for many specialized applications. Probably more make-and-break electrical contacts are made from fine silver or silver alloy than from all other contact materials combined.

Grades

Silver is classified by grades based on the silver content in parts per thousand (although impurities are reported in percent). The commercial grades are Fine Silver and High Fineness Silver.

Fine silver is the grade ordinarily supplied. It contains at least 999.0 parts silver per thousand. Although copper is the major impurity, any of the common base metals can be present. Impurity limits are not normally specified, but elements that may be present and their typical quantities are given in Table 1.

High fineness silver is a loose term referring to any silver containing at least 999.5 parts per thousand. This grade is sold at a premium price and the fineness required should be specified. A high fineness silver containing 999.9+ silver is the purest silver obtainable in quantity. Since this material is specially selected from commercial lots of high fineness silver, it may not be available for immediate shipment.

In addition to metallic impurities, fine silver may contain small quantities of oxygen or hydrogen. Like copper, silver containing oxygen is subject to hydrogen embrittlement. Normally, the oxygen content of silver is much lower than that of tough pitch copper, however, and the effect is less pronounced. Deoxidized grades of fine silver can be obtained for applications where hydrogen embrittlement is possible.

Fine silver is available commercially in the form of bars, rod, sheet and strip, foil, wire, tubing, shot, grain and flake powder.

Properties

Physical properties of silver are given in Table 2. On a volume basis, fine silver has the best thermal and electrical conductivities of all metals. Although electrical conductivity averages 105.2% IACS, the value ranges from 98 to 108% depending on purity and temper. Cold working lowers the conductivity of silver more drastically than of copper.

The effect of wire drawing on properties is shown in Table 3. With increasing reductions by drawing, strength and hardness increase while ductility and electrical conductivity fall.

Like copper, silver is sometimes specified by temper, a number being used to indicate the degree of cold working. Relationship between temper and reduction by cold working is shown in Table 3. In this table, 0 is equivalent to annealed temper, 4 to hard temper and 6 to spring temper.

The effect of annealing on properties of silver wire is indicated in Table 4. Complete softening is achieved at relatively low temperatures.

Fine silver is particularly resistant to caustics and to a wide variety of acids and other corrosive materials. Silver dissolves rapidly in nitric acid and more slowly in hot concentrated sulfuric acid. It tarnishes rapidly in the presence of sulfur and sulfur-bearing compounds. However, it oxidizes slowly in air, and the oxide decomposes at a relatively low temperature, so that the parent metal is again exposed. This is a valuable asset when silver is used as a contact material.

Fabrication

Casting — Fine silver can be cast by conventional methods. To prevent oxidation during melting, the metal should be protected with a layer of charcoal or by melting under a neutral or reducing gas. Complete deoxidation can be obtained by the addition of lithium or phosphorus in sufficient quantity to leave a residual content of not more than 0.01%.

Working—Because of its excellent ductility, silver can be

readily hot or cold worked. Although drastic reductions by cold rolling or drawing are possible between anneals, the heat generated may be sufficient to cause the metal to self-anneal. To obtain maximum hardness, cold working must be performed with sufficient care to prevent an appreciable rise in temperature.

Although silver has excellent ductility, its relatively low tensile strength must be considered in performing such operations as deep drawing and forming. Lighter reductions must be used in deep drawing silver than are used with copper or brass, for example, and as many as a third more dies may be required to produce a drawn shell of a given size. On the other hand, silver work hardens at a lower rate, and more operations can be performed between anneals.

Machining—Being a soft, tough metal, silver is relatively difficult to machine. In the annealed condition, galling and seizing of the tool or tearing of the surface are problems. Machinability is greatly improved by using silver that has been cold worked. A lubricant such as lard oil is necessary to prevent chip welding. Tools suitable for machining copper are satisfactory.

Joining—Fine silver can be soldered without difficulty using standard tin-lead solders, although annealing occurs even at the temperatures reached in these operations. Any standard BAg filler metal can be used in brazing.

Welding can be done by resistance methods and by atomic hydrogen or inert-gas-shielded arc processes. Care is necessary to prevent oxygen absorption that would result in formation of brittle joints.

Annealing—Fine silver can be annealed at relatively low temperatures, the range 400 to 800 F being recommended. As indicated in Table 4, the best combination of strength and ductility is achieved by annealing in the range 700 to 800 F. Little additional softening occurs at higher temperatures, and ductility is actually reduced. Also, the grain growth that occurs at temperatures above 800 F is objectionable, particularly if additional working of the material is necessary. Working of coarse grain material may cause the formation of "orange peel" on the surface. High temperatures also induce welding of adjacent surfaces, particularly in thin sheet or fine wire. The lighter the gage, the lower should be the annealing temperature.

TABLE 1—IMPURITIES IN FINE SILVER

Element	Impurity Content, %	
	Usually	Rarely as much as
Copper	0.05	0.09
Lead	0.004	0.04
Bismuth	0.001	0.01
Iron	0.001—0.003	0.005
Magnanese	<0.001	0.003
Nickel	<0.001	0.002
Magensium	<0.001	0.002
Silicon	<0.001	0.002
Tin	Not usually found	—
Zinc	Not usually found	—
Gold	Trace	—
Palladium	Trace	—
Selenium	0.0002	—
Tellurium	0.0002	—

TABLE 2—PHYSICAL PROPERTIES

Melting Point, F	1761
Boiling Point, F	3551
Density, lb/cu in.	0.378
Elec Cond % IACS	105.2[a]
Elec Resist, microhm-cm	1.59[a]
Spec Ht, (68 F) Btu/lb/°F	0.0562
Ther Cond, Btu/sq ft/ft/hr/°F	242
Coef of Ther Exp (32-212 F), per °F	10.5×10^{-6}
Mod of Elast, psi	10.3×10^{6}

[a]Conductivity varies from about 100 to 108% IACS depending on purity and temper.

TABLE 3—EFFECT OF DRAWING ON PROPERTIES OF WIRE
(Original Wire Diameter = 0.091 in.)

Reduction by Drawing, %	Temper (numbers hard)	Ten Str, psi	Elong (in 2 in.), %	Rockwell Hardness (15T)[a]	Elec Cond, % IACS
(Annealed)	0	25,900	50	14	102.8
10.2	½	29,000	34	52	102.2
20.0	1	33,300	13	59	101.0
37.0	2	40,600	5	66	99.7
48.6	3	43,200	5	68	99.5
60.0	4	45,000	4	70	99.4
68.5	5	46,900	4	71	98.4
74.0	6	49,200	4	71	98.1

[a]Hardness values determined on longitudinal sections made by filing flat faces parallel with the axis of the wire. Hardness values on sheet and strip having the same reductions are approximately the same as those obtained on flat faces filed on wire.

TABLE 4—EFFECT OF ANNEALING ON PROPERTIES OF WIRE
(Wire Diameter = 0.091 in.)

Anneal Temp, F[a]	Tensile Strength, psi	Elongation (in 2 in.), %
None	43,200	5
400	40,300	10
500	27,500	43
600	25,500	52
700	25,200	55
800	25,000	54
900	24,550	52
1000	24,300	43
1100	24,750	44
1200	25,350	39
1300	25,800	32

[a]Annealed ½ hr starting with material 8 numbers hard.

Applications

Applications of fine silver are based to a large extent on electrical properties. One of the major uses is in electrical and electronic equipment where maximum conductivity is of paramount importance. Fine silver contacts are particularly suited for light pressure, light duty devices or for intermittent service. Typical electrical applications are light duty relays for aviation equipment, fluorescent lamp controls, electromagnetic counters, protective devices for motors, refrigerator thermostats and telephone relays.

Aside from electrical and thermal uses, silver is highly useful for corrosion resistance applications. It is widely used in tubing, piping and linings for handling corrosives in the chemical process industries.

New Uses of

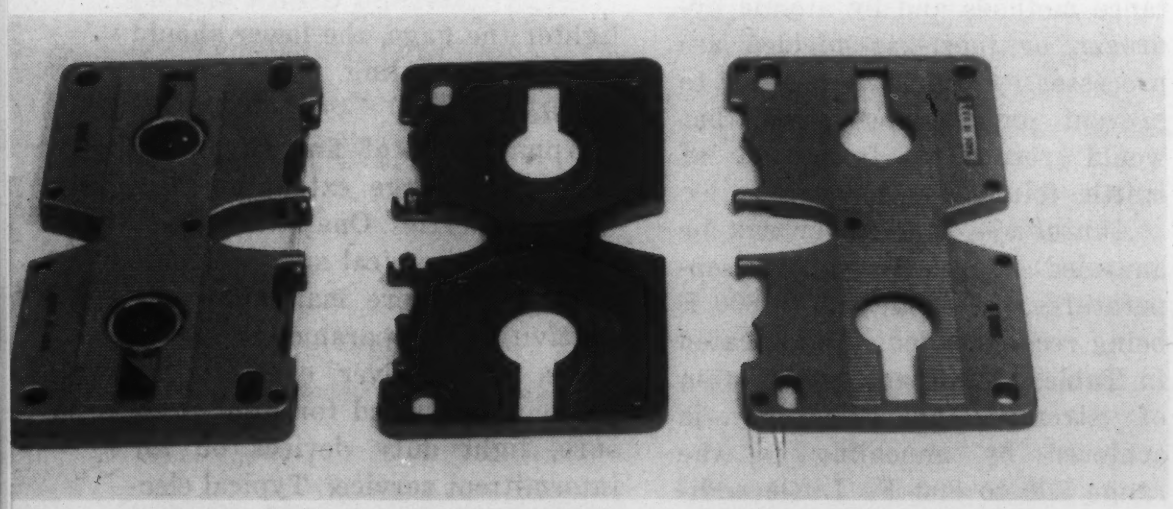
Applications continue to increase as potential users become more familiar with the properties of this metal—lightest of all the structural metals. Here is a report on some recent uses.

■ A distributor who sold less than 50,000 lb of magnesium in 1950 expects to sell a million pounds in 1957 for one application alone. By 1960, Dow Chemical Co. estimates, nearly 200 million pounds of magnesium will be consumed annually. This increase in the use of magnesium has been due not only to the development of better alloys but also to an increased awareness of the excellent properties that magnesium offers.

Briefly, magnesium is the lightest structural metal. It has a specific gravity of only 1.74; aluminum, the next lightest metal, is 1½ times heavier; titanium is 2 times heavier; zinc is 3 times heavier; and iron and steel are 4½ times heavier. Magnesium can be cast by sand, die and permanent mold methods; it can be extruded into a variety of shapes; and it can be rolled into sheet, plate and strip. It is readily forged and can be formed by drawing, bending, spinning and impact extrusion. It can be joined by gas, arc and electric welding, as well as by brazing, bolting and riveting. Machinability of magnesium is unsurpassed by that of any other structural metal.

The main factors limiting the use of magnesium are high cost of the material, the fact that it has to be worked hot, the extra care necessary to prevent fire, corrosion problems, and the necessity of using thick sections to overcome low rigidity.

Some of the newest and most interesting applications for magnesium were discussed at the recent Annual Convention of the Magnesium Association in Chicago. Here are brief summaries of these reports.



***Magazine** for recording machine is cast in identical halves of magnesium. Wall thickness at thinnest point is 0.060 in.*

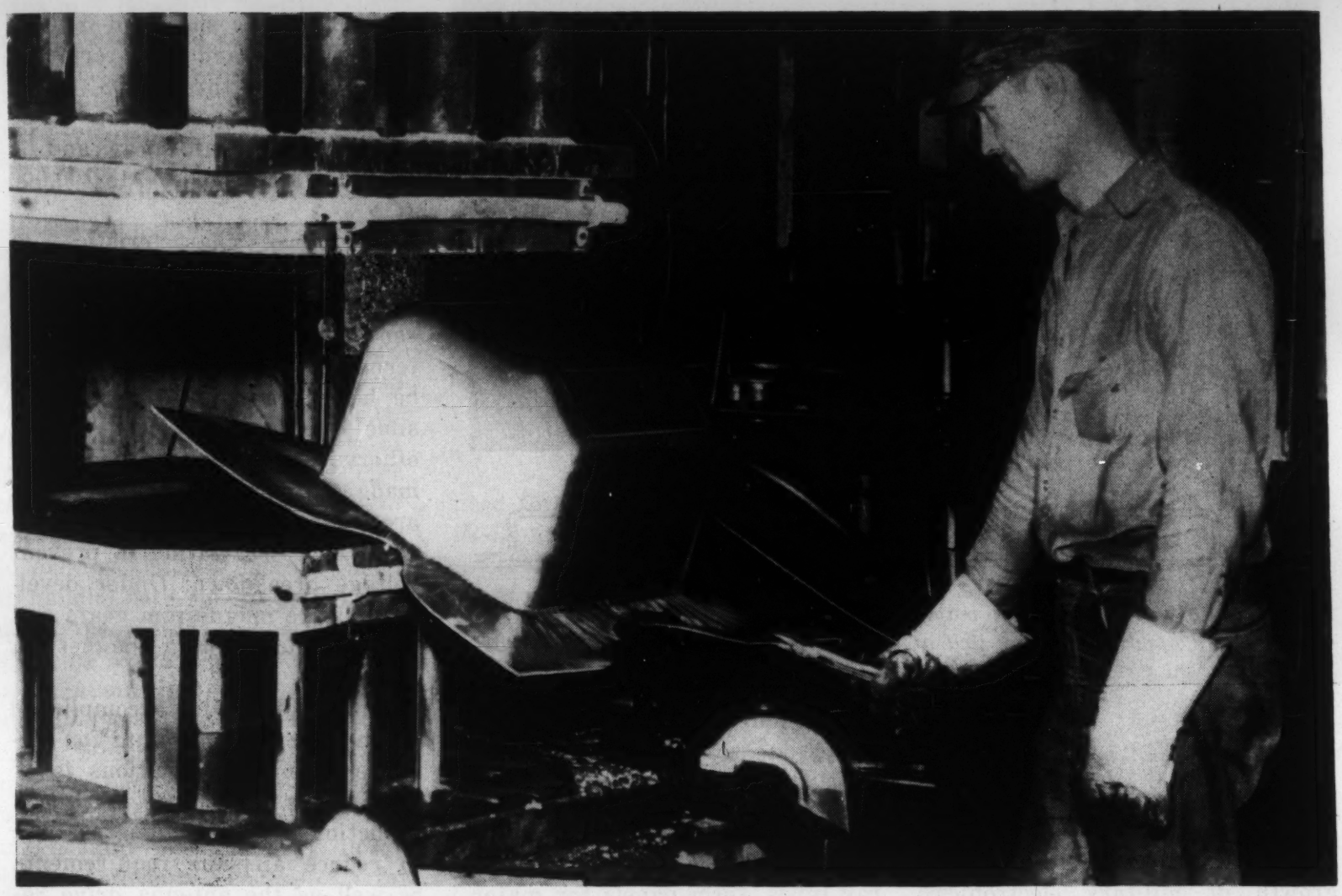
Dictating, recording equipment

Fifteen magnesium die castings are used in two portable magnetic tape recorders. Magnesium was chosen because it is nonmagnetic and provides maximum rigidity and dimensional stability with minimum weight and thickness.

The low electrical conductivity of magnesium is an important factor. Magnetic recording and reproducing heads are very sensitive to magnetic fields from motors, solenoids and transformers. These unwanted magnetic fields cause hum and what might be called static. Magnesium minimizes the effect of stray magnetic fields within the recording machine. In addition, it permits easy "erasure" of the tape.

Major advantage of the use of magnesium is the reduction in weight. Previously this type of machine used aluminum and zinc die castings for the structure, and steel for most of the operating mechanisms. By changing all of the aluminum and zinc die castings in an earlier model to magnesium, and the steel to magnesium and aluminum, the weight was reduced from 21 to 12 lb. Moreover, this weight reduction was accomplished with no increase in manufacturing cost. The increased raw material cost was absorbed in part by improved manufacturing methods, and in part by the decrease in machining time.

Magnesium



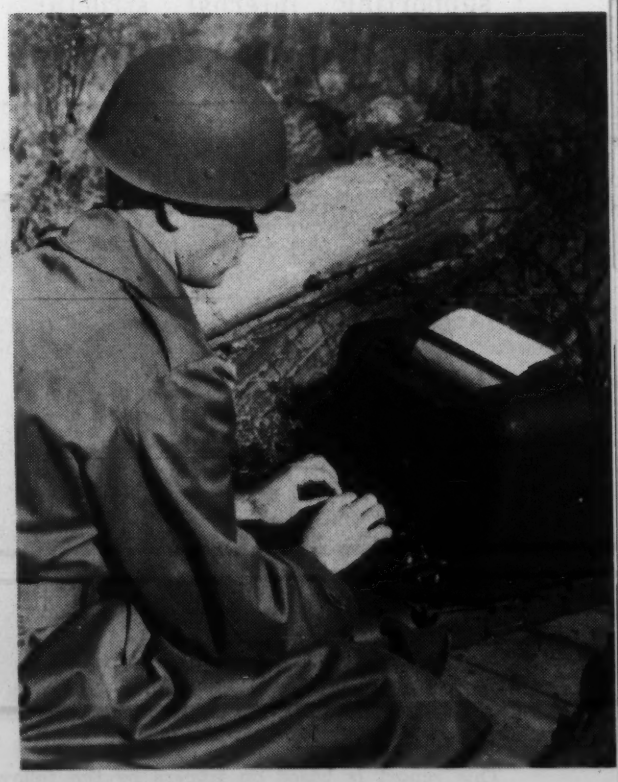
Cover *for teleprinter is removed from the press after drawing.*

High speed teleprinters

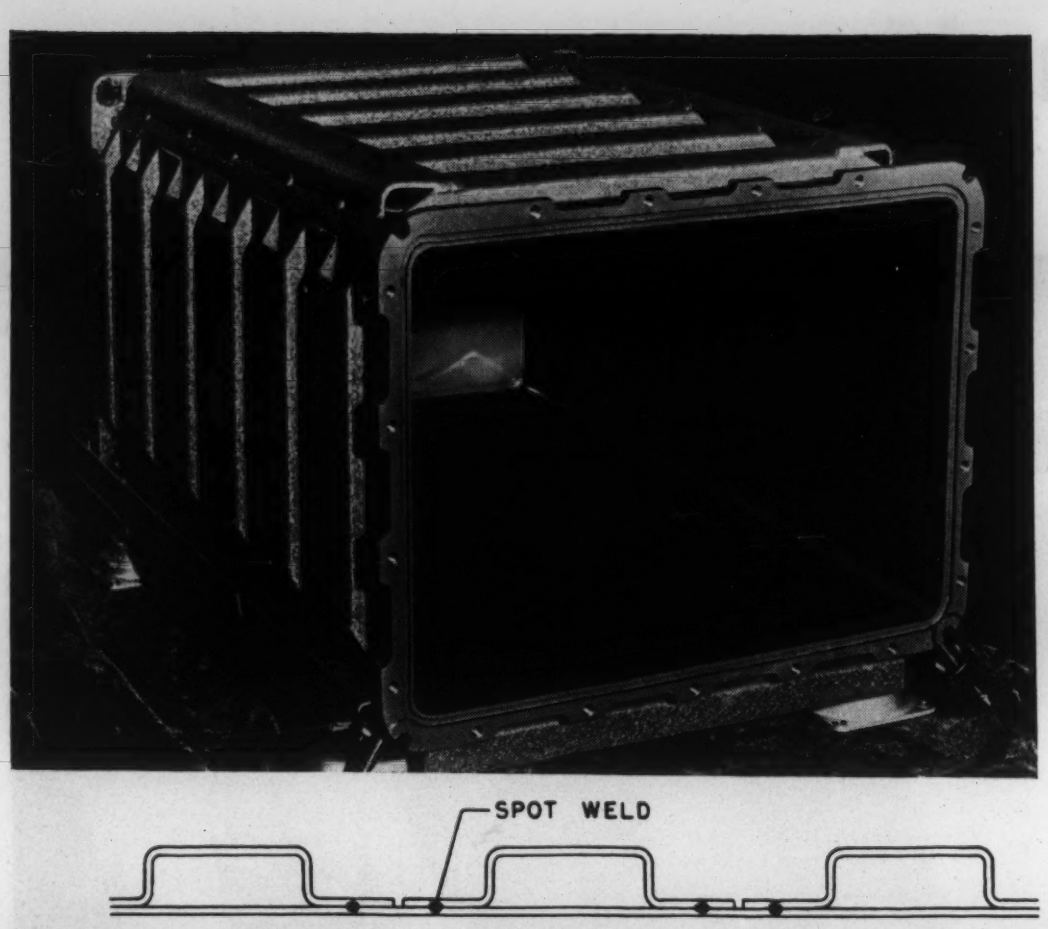
The high speed teleprinters used by the U.S. Army Signal Corps must meet certain rigid specifications: they must be light and rugged; they must be able to withstand a parachute drop; they must be immersible so they can be floated ashore; they must withstand a drop from the tail gate of a truck; and they must be portable. Magnesium has been successfully adapted to meet all specifications.

The actual weight of the teleprinter shown in the accompanying photograph is 47.5 lb. A companion piece of equipment, a typing perforator, weighs 97 lb. The two pieces of equipment represent a total reduction in weight over previous models of more than 465 lb.

The drawability and machinability of magnesium proved to be distinct advantages in the manufacture of this equipment. The material used for the covers is 0.065-in. annealed sheet. Drawing is done with heated sheet and dies in one draw operation. If such pieces were made of steel or aluminum, three draw operations with additional tooling and intermediate annealing operations would probably be required. In addition to deep drawn parts, the unit is composed of sand cast frames, flat stampings, die castings and one impact extrusion.



***Teleprinter** set up in field.*



***Power supply housing** uses magnesium extrusions welded together along diametrically opposite corners and at the junction of mating sections. Back cover and front flange are magnesium castings.*

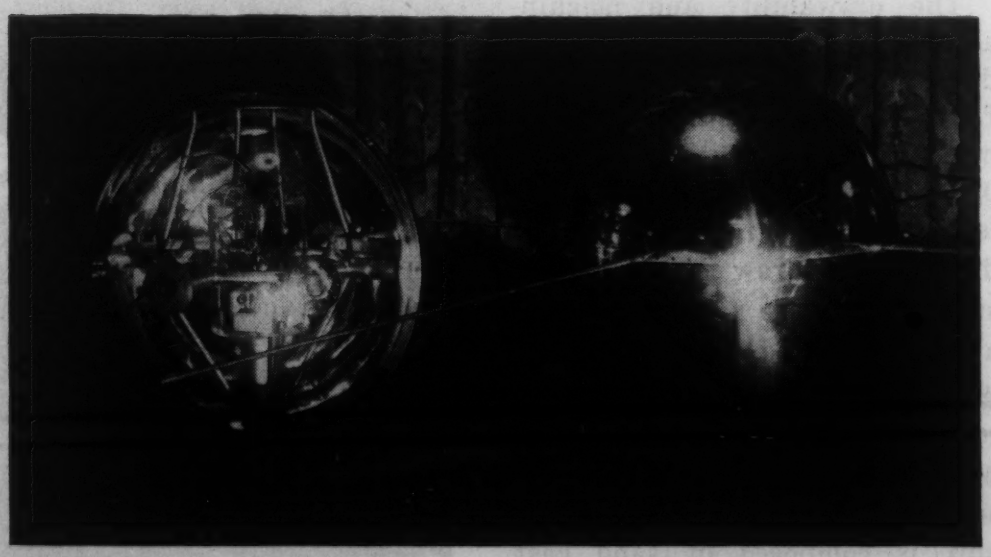
Military electronics equipment

The use of magnesium castings in military electronics equipment has expanded parallel with the growth of military electronics. The castings are used primarily as bases for shock mountings and vibration isolators, frames for supporting internal structures and subassemblies of major units, gear housings, pressurized housings, retainers for large cathode ray tubes, form panels for major units and flanges for waveguide sections.

Some of the environmental conditions under which these products are tested and must function are: 1) temperatures from -85 to 160F, 2) vibrations from ten to as high as several thousand cycles per sec with amplitudes ranging from 0.008 to 0.060 in., 3) shocks of 5 to 30 G's 4) short and long term humidity cycling through 98% R.H. at 130 F for periods up to 30 days, 5) 50-hr salt spray, and 6) altitudes from sea level to 100,000 ft.

The two characteristics of magnesium that are of importance in such applications as shock mountings are its good internal damping and its ability to be heat treated; both make possible lighter sections than could otherwise be tolerated. Housings made of extrusions and castings are commonly used on units that require pressurization to prevent voltage breakdown. Under development are magnesium gears and shafts running in a magnesium housing.

The weight saving accomplished by the use of magnesium for airborne antenna applications is of tremendous importance. With this reduction in weight, it is possible to reduce airplane requirements as well as the antenna drive requirements. In cases where sector scanning is a function of the radar system, the reduced weight means improved performance.



Earth satellite

Tests have indicated that this lightweight magnesium structure (right) will efficiently protect the many complicated and delicate instruments (left) against the great stress and heat that will be encountered in the earth satellite's flight through space.

This report is based on papers by the following: D. R. Cole, T. A. Brouillette & Son; J. W. Tweedy, Redmond Motors Co.; Arthur F. Maynard, General Electric Co.; R. E. Short, Kleinschmidt Laboratories, Inc.; Frederick W. Roberts, Dictaphone Corp.; Freeman M. Guest, Model Engineering & Mfg. Inc.; and John R. Gibson, Reliance Magnesium Co.

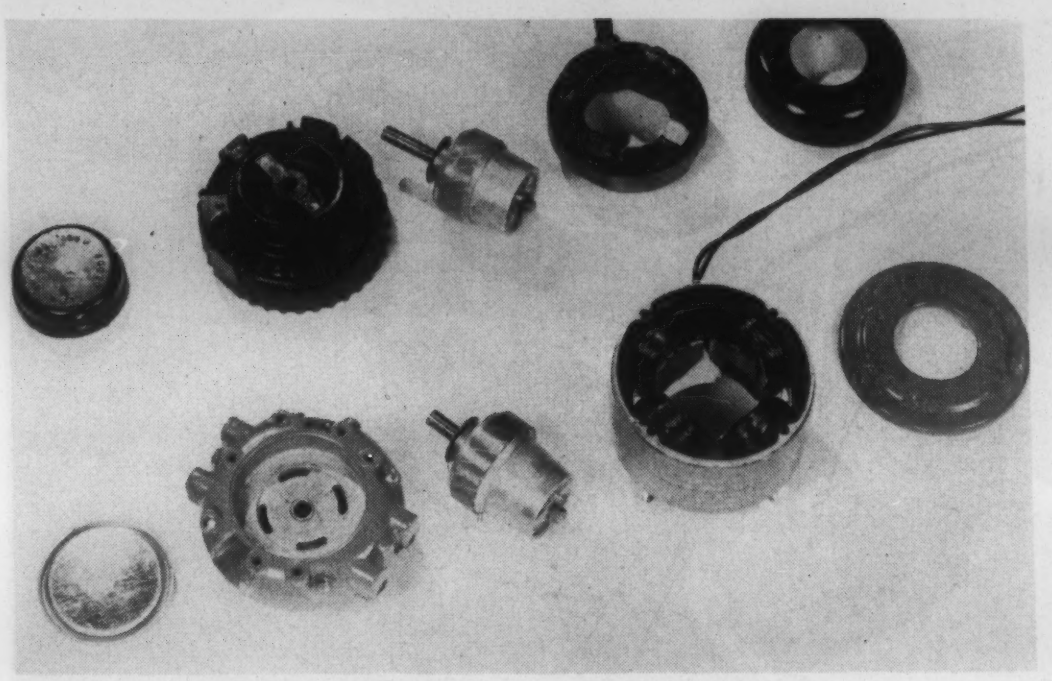
Electric motors

As a result of an exhaustive series of tests started in 1949 and continuing until last year, Underwriters' Laboratories has established that magnesium enclosure walls may be safely used for electric motors rated up to and including 1 hp. Redmond Motors Co. is presently producing many types of motors that use magnesium as the structural material. The main advantages of magnesium these motors have exploited are light weight, machinability and castability.

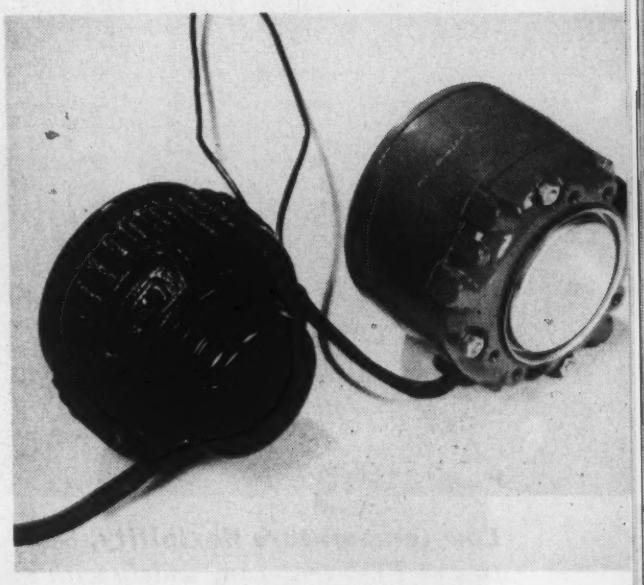
Light weight—On one model, a single gray iron casting once served as both stator and end frame. The new motor has separate stator and frame—both of magnesium die castings. This provides a reduction in weight of approximately 50%. In addition to making the new motors easier to handle, both for assembler and user, the weight reduction cuts shipping costs.

Machinability—Both feeds and speeds have increased. In some cases, the quality of the machined part is better, and in all cases tool life is prolonged. Because magnesium machines dry in all the operations necessary for making these motor frames, the need for cutting fluid and coolant is eliminated.

Castability—Magnesium rarely miscasts, but when it does it can be easily stripped and the laminations salvaged. Magnesium solidifies rapidly, does not tend to crack when cooling to room temperature, and has low porosity and a good surface. By casting the magnesium it was possible to produce an integral stator. A riveted design sometimes leads to misalignment of the motor.



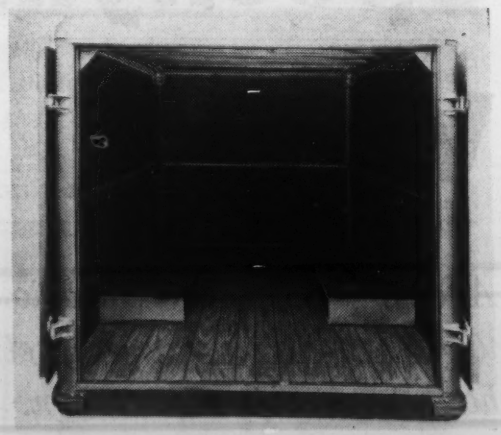
Motor *uses magnesium die castings (foreground) to replace gray iron castings. Old and new assemblies are shown below.*



Truck bodies

It has been determined that for every 1500 lb of body weight saved at present prices, the cost per mile traveled is reduced by 1¼ cents. The magnesium body provides a weight saving over steel or aluminum bodies of from 800 lb on smaller units to as much as 3200 lb on the large units. Thus, if a truck travels 40,000 miles per year, a saving of $500 may be realized. One company claims that it actually has been saving 9 cents a mile on the trucks it converted to magnesium bodies.

By using ⅛-in. sheet (compared to 1/32 to 1/16 in. used in the conventional body), the necessary rigidity is achieved without the usual supporting framework—and with weight savings. Since there are no sideposts, all welding and riveting is eliminated. Instead, aluminum fasteners are used. This reduction in parts and the resulting decrease in the number of fasteners required offer several advantages. For the manufacturer, production is speeded; for the truck user, the simplified construction means more clear space for cargo. The thick magnesium skin gives the cargo better protection as well. It is more puncture- and dent-proof than the skin of the conventional body, and wrinkling presents no problem.



Truck body *of magnesium is light, compact and sturdy.*

Low temperature flexibility, *being checked here, is one of the many properties of PVC that vary widely with composition.*

What you should know in . . .

Specifying Vinyls

Are your PVC specifications realistic? This article tells what properties you can get and what properties you may have to sacrifice in return.

by W. Waychoff and P. Spink, *Technical Service, Monsanto Chemical Co.*

■ Polyvinyl chloride plastics are highly complex. Because of their complexity, the designer should for the most part, specify end properties only, and let the materials supplier or the molder select or develop the appropriate PVC formulation. To specify properties intelligently, however, the engineer must know the limits on properties obtainable and the compromises that are necessary to obtain the optimum combination of properties desired.

The complexity of polyvinyl chloride arises from the fact that the base resin may be modified with plasticizers, stabilizers, fillers, pigments and lubricants, a change in any one of which can radically affect the end properties of a part. Because of the countless number of property combinations that can be obtained by varying the ingredients and their relative proportions, this article emphasizes simply the maximum values obtainable. Also, most of the discussion is devoted to those properties that have been limiting factors in the broader satisfactory use of PVC, i.e., temperature resistance, light stability, stain resistance, etc.

Being maximums, the values given here for various properties will not always be obtainable. For the most part, the maximum value obtainable for a particular property will depend on the magnitudes of the other properties required. All formulations are compromises, and most values given here are for compounds formulated specifically for that particular property.

Mechanical properties

Though PVC is not primarily a structural material, mechanical properties must be considered. Within the limits of the material, mechanical properties of PVC can be altered over a wide range by varying the plasticizer content. Rigid (unplasticized) PVC has a maximum tensile strength of 6000 to 8000 psi, elongation of 2 to 10% and Shore A durometer hardness of 100. Addition of plasticizers results in some sacrifice in tensile and hardness, but

improves elongation. The accompanying table illustrates the effects on tensile strength, elongation and hardness of adding different proportions of a general purpose plasticizer.

Tear strength can be particularly important in film or in sheet where sewing or dielectric sealing is to be used. Tear strength also is affected by the plasticizer, the highest value being about 555 gm per mil. Effect of plasticizer on tear strength, as measured by the Elmendorf tear test, can be shown by the following comparison:

Plasticizer	Tear Strength, gm/mil
Polymeric plasticizer	155
Tricresyl phosphate	270
Dioctyl phthalate (DOP)	375
Aryl alkyl phosphate	530
Butyl benzyl phthalate	555

The other properties primarily affected in compounding for maximum tear strength are water resistance, which is slightly affected, and low temperature flexibility, which does not attain a maximum.

Temperature limitations

A thermoplastic material, PVC properly compounded retains dimensional stability up to a maximum temperature of about 250 F. Actual temperature at which a formulation can be used depends on the design stresses. In most applications where partial stressing is involved, PVC is limited to service temperatures below 212 F. In stressed applications, the safe temperature limit is generally about 175 F.

The maximum temperature at which a specific formulation can be used depends on the type of plasticizer used. In general, the higher the boiling point or the lower the volatility of the plasticizer, the better the retention of physical properties and the longer the service life of the product at elevated temperatures.

Following is a comparison of two PVC electrical formulations using different plasticizers (DOP vs diisodecyl phthalate—electrical grade) which shows the effects on elongation of aging for seven days at 250 F.

	DOP	DIDP-E
Original elongation, %	343	332
Elongation after aging 7 days at 250 F	31	312

The DIDP-E formulation retained 94% of its original elongation, whereas the DOP formulation retained only 9%, at which point it was too brittle for use.

To the user, the most important result of exposure to high temperatures is degradation of end properties. However, high temperatures during processing also can cause chemical degradation of the resin, resulting in discoloration. Degradation during processing can usually be avoided by incorporating the proper stabilizer in the formulation.

One of the major problems in formulating for high temperature resistance is obtaining adequate low temperature flexibility.

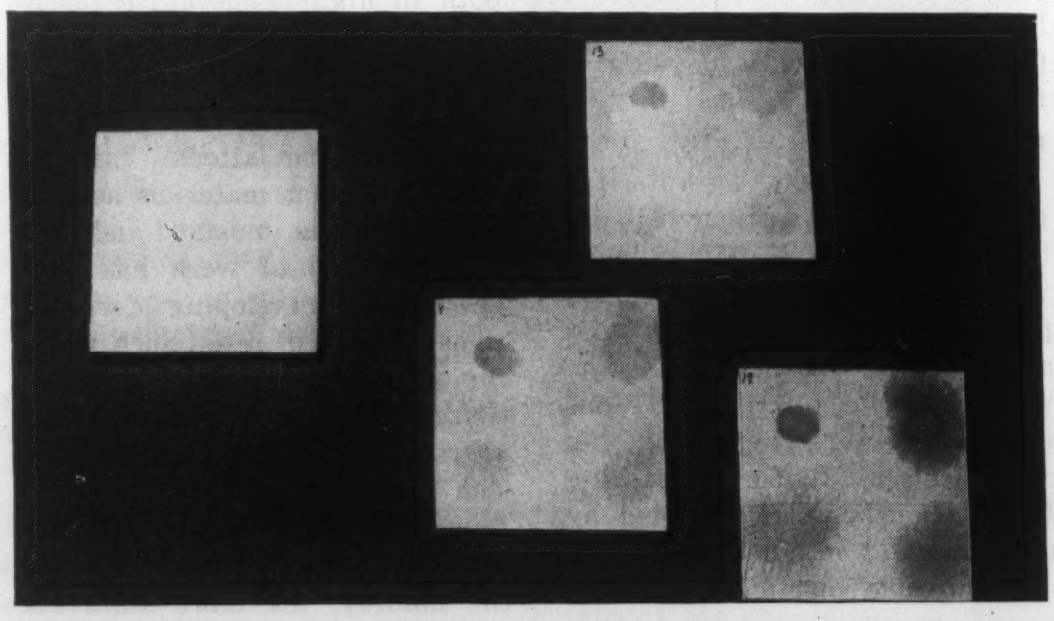
Inadequate low temperature flexibility may cause undesirable stiffness at low temperatures or complete fracture due to embrittlement. The lowest temperature at which practical flexibility is obtainable is about −75 F; this level can be attained by using adipates, azelates, sebacates or other low temperature plasticizers. No other modifying ingredient plays as important a part as the plasticizer in low temperature flexibility. The effects of the plasticizer used can be seen in the following results obtained with a Clash-Berg instrument on PVC systems formulated with three different plasticizers:

Plasticizer (67 pts to 100 pts resin)	Lowest Flex Temp, F
Tricresyl phosphate	–10
Dioctyl phthalate	–37
Dioctyl adipate	–66

When formulating for low temperature properties allowances must be made for some plasticizer migration and extraction, and a sacrifice in hardness.

Light stability

Though the light stability of PVC systems is generally consid-



Improvements in stain resistance *possible are shown by these four floor tile samples, all subjected to lipstick and yellow, brown and blue dyes. The four samples were formulated identically except for the plasticizer used.*

EFFECT OF PLASTICIZER CONTENT ON MECHANICAL PROPERTIES[a]

Property	Plasticizer Content, %			
	20	30	40	50
Tensile Strength, psi	3700	3000	2000	1300
Elongation, %	210	325	400	450
Hardness, Shore A	100	87	74	60

[a]Plasticizer is DOP (dioctyl phthalate).

ered to be excellent, it is affected to some extent by choice of plasticizer and to a greater extent by choice of stabilizer. For example, there has been developed recently a new stabilizing system incorporating an ultraviolet screener which triples the light stability of previous PVC compositions (see M&M, July '56, p 218). Under test, the control formulation, consisting of a system considered to be outstanding in stability, failed after about 1900 hr in the weatherometer. The formulation containing the new stabilizing system withstood 5600 hr in the weatherometer before failure.

Light stability can also be improved by using the proper plasticizer. Illustrative of the effect of the plasticizer on light stability is an experiment in which the control formulation, plasticized with a mixture of dioctyl phthalate and dioctyl adipate and incorporating a good general purpose light stabilizing system, failed after 18 months of outdoor exposure. An experimental formulation in which a portion of the DOP was replaced with aryl alkyl phosphate has withstood over 36 months exposure to date with no sign of failure.

Flame resistance

Polyvinyl chloride resin itself is flame resistant, i.e., though it will burn, it is self-extinguishing when the flame is removed. Many plasticizers, such as phthalates and adipates, are flammable, and when added to vinyl formulations inhibit this self-extinguishing characteristic. Self-extinguishing formulations can be obtained by using any of a number of such nonflammable plasticizers as tricresyl phosphate, aryl alkyl phosphates, chlorinated biphenyls and chlorinated paraffins. (Modifiers such as antimony oxide can also be used to retain the self-extinguishing characteristic.) Since there is a wide variety of such nonflammable plasticizers, other properties of flame resistant grades of PVC can be specified over a relatively wide range.

Dielectric properties

Electrical resistance of PVC is also affected by choice of plasticizer. This is illustrated by the following data comparing the insulation resistance of a DOP-plasticized composition with that of a typical 60 F wire composition which is plasticized with a blend of DOP and HB-40:

	DOP	DOP-HB-40 Blend
Dry Slab Resist, 10^{13} ohm-cm	8.34	21.4
Insul Res, megohms/1000 ft, after water immersion for:		
24 hr at 77 F	643	1650
24 hr at 122 F	51	187
1 wk at 122 F	81	314
6 wk at 122 F	109	396
12 wk at 122 F	99	342

Though special low volatile plasticizers have been developed for PVC insulation to be used on 220 F wire, compounds with superior dielectric properties can be formulated for 60 F wire because there is a wider choice of plasticizers available for use in that temperature range. For compositions possessing maximum electrical resistance, some sacrifices must be made both in high temperature resistance and in low temperature flexibility.

Stain resistance

Vinyl formulations can be stained by such materials as road tars, cosmetics, mustard and dirt. A great deal of work has been devoted to developing formulations which will resist such staining, particularly in floor tile. Plasticizers have a substantial effect on resistance of PVC to staining. The following ratings show how four floor tile formulations compare in stain resistance (the lower the number, the more stain resistant the product):

Plasticizer Used	Stain Resistance Rating
Butyl benzyl phthalate	1.0
Tricresyl phosphate	3.4
Dioctyl phthalate	12.0
Didecyl phthalate	28.3

Water resistance

The problem involved in the resistance of vinyl formulations to water and soapy water is plasticizer extraction: certain types of plasticizers are more soluble in water and soap solutions than in the vinyl. Until recently DOP imparted about the maximum resistance to soapy water that could be obtained with a general purpose plasticizer. However, there are now two decyl alcohols that provide greatly superior water and soapy water resistance. Following are comparative data on two formulations, one plasticized with DOP, the other with diisodecyl phthalate (DIDP). The data on cleansers were obtained with 1% solutions of commercial household laundry soaps.

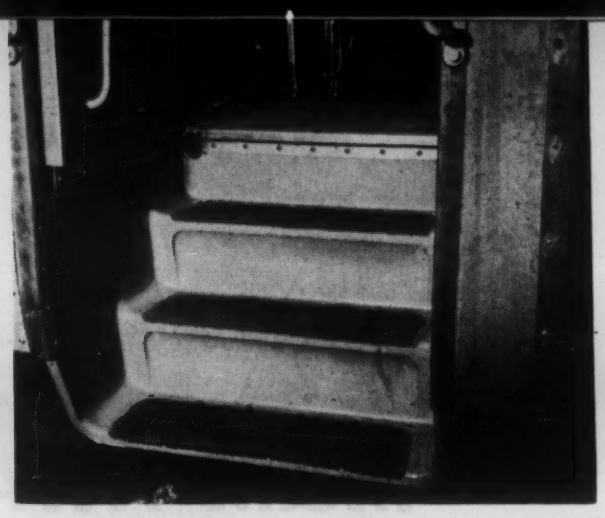
	DOP	DIDP
Extracted by water, %	0.44	0.25
Extracted by cleanser A	11.1	3.3
Extracted by cleanser B	7.4	5.0
Extracted by cleanser C	1.5	<0.1

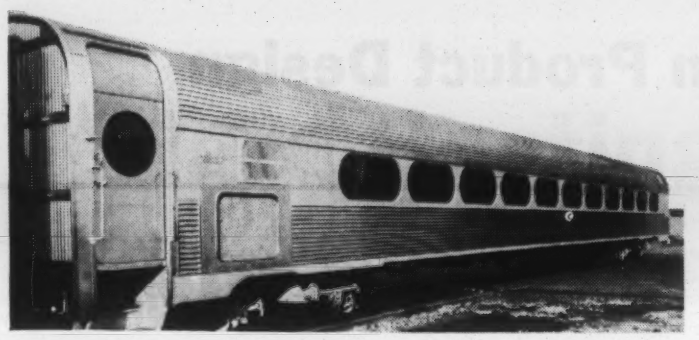
Fusion rate

Though the designer or engineer is not concerned directly with fusion rates of vinyl formulations, fusion rate does determine production speed and thus affects the economics of materials selection. The number of parts per hour from a given machine varies greatly depending on the activity of the plasticizer as a solvent for the resin. The problem is to obtain the maximum production rate, yet maintain the quality of the product. If production rates are too high the resin may not solvate to the maximum degree and optimum physical properties will not be developed. The following data indicate the variance among fusion rates obtainable with different plasticizers:

	Time to Fuse, sec
Butyl benzyl phthalate	47
Tricresyl phosphate	56
Dioctyl phthalate (DOP)	71
Polymeric plasticizer	283

Of course, fusion rate and thus production rate cannot weigh too heavily in specifications, since primary emphasis must remain on properties. As in the case of other properties, compromises must be made to obtain the optimum product.

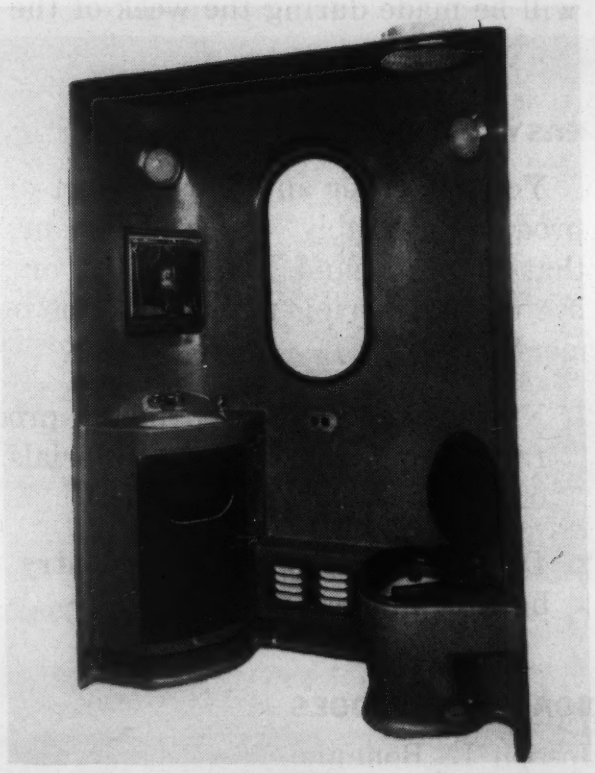




Stainless + plastics make lightest train yet

By combining an all-stainless steel structure with an interior almost entirely composed of plastics, Budd Co. has produced a railway passenger car that is claimed to have the lightest weight per passenger (595 lb) of any railway car ever built in this country. Called "Pioneer III," the 88-passenger car is a basic design which can be adapted to nearly any type of railway passenger service. A train of seven cars would show an over-all saving in weight of nearly half a million pounds over other "lightweight" trains.

Stainless steel—*Principal structure of the car, welded of high tensile stainless steel, incorporates a divided center sill, i.e., two strong members extending uninterruptedly from end to end of the car and connected directly to collision posts at the ends. The two center sills are connected by corrugated stainless steel which stabilizes their flanges and provides a box to house electric train lines. Pier panels are formed of stampings which allow insetting of rubber window moldings. A newly designed four wheel truck, incorporating air springs and external disk brakes, weighs only one third as much as conventional trucks.*



Reinforced plastics—*Interior components of the car formed of reinforced plastics include the stairwell (top) and bathroom unit (bottom) both molded in one piece; a single reinforced plastics panel which forms the lower portion of the baggage rack, incorporating a molded-in opening to accommodate the window; a second panel, which combines the upper portion of the baggage rack, the ceiling and half of the air duct; lighting fixtures; and bucket type seats. Seat cushions are vinyl foam; upholstery is vinyl-coated fabric.*

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M&M AWARDS COMPETITION

for the

Best Use of Materials in Product Design

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10 Citations— **$50** *each & certificate*

Award winning entries will be published in the May issue of MATERIALS & METHODS. Awards will be made during the week of the Design Engineering Show, May 20-23, 1957 in New York City.

EASY TO ENTER—

You can enter any new product or redesigned product, assembly, subassembly, or single part that shows sound, imaginative or progressive use of engineering materials. The only requirements are:

1. You must be employed in the product manufacturing industries. (Materials producers or suppliers are not eligible.)
2. Design or redesign of the entry must have been completed during 1956.

BOARD OF JUDGES

Joseph L. Bonanno,
Chief Engineer, Lionel Corp.

John P. Nielson,
Chairman, Dept. of Metallurgical Engineering, New York University

John B. Seastone,
Director, Technical Div., Olin Mathieson Chemical Corp.

Walter Dorwin Teague,
Industrial Designer

HERE'S HOW—

No fancy entries are required. To enter, simply supply the following information:

1. A detailed description of the product, including photographs or drawings. If the entry is a redesign, provide before and after illustrations if possible.
2. A description of requirements in service and/or fabrication that must be met by the product and the material.
3. A description of the previously used materials (if entry is a redesign).
4. A description of the material or materials selected for the product entry.
5. An explanation of why the material or materials were selected for the product. Describe the benefits gained through the choice. Back them up with evidence — facts, data, charts, tables on performance, quality or cost.

DEADLINE EXTENDED

In response to many requests, the deadline for the Awards Competition has been extended from Jan 31 to Feb 15, 1957. Entries must be postmarked no later than that date.

Mail entries or write for further information to Awards Editor, Material & Methods, 430 Park Ave., New York 22, N. Y. (This competition was first announced in the November, 1956 issue.)

This manual covers . . .

Hard Coatings and Surfaces for Metals

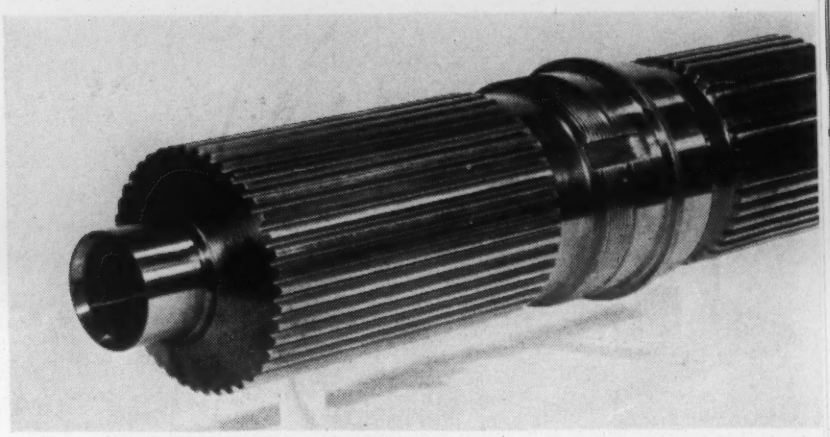
Here is a survey of the major types of hard coatings and surfaces that can be used in the design of metal products. For each type of surface, it tells:

1. *What metals can be treated*
2. *Hardness and thickness*
3. *Wear and corrosion properties*
4. *Chief advantages and limitations*

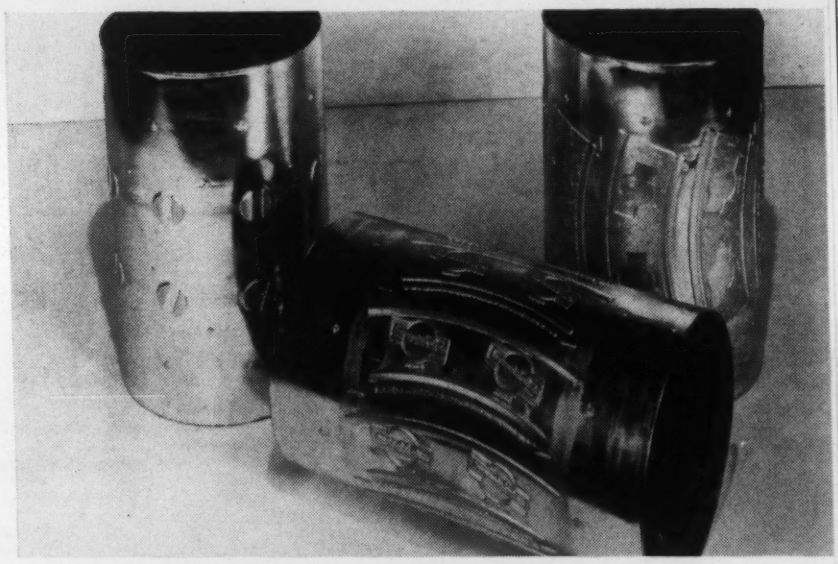
by Robert J. Fabian,
Associate Editor, Materials & Methods

MATERIALS & METHODS MANUAL NO. 134
JANUARY 1957

. . . hard facings



. . . diffusion coatings and heat treated surfaces



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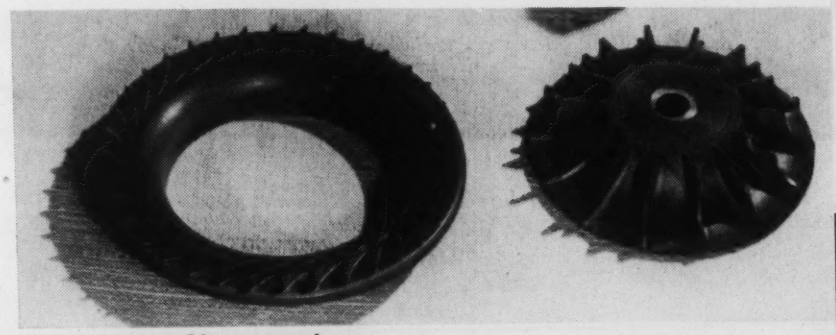
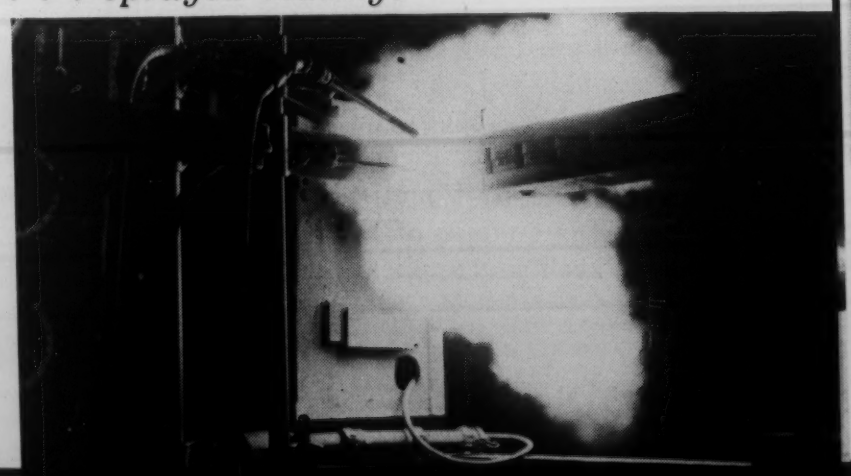


. . . anodic coatings

. . . sprayed coatings



Wall Colmonoy Corp.

Plow share *hard faced with chromium-tungsten-cobalt alloy has low coefficient of friction combined with high abrasion resistance and high impact resistance.*

■ Many metal parts and products need a hard surface to protect them from the rigors of service environments. A hard surface can be obtained by 1) using a base material that has the required hardness to begin with, or 2) hardening the surface of a softer metal. The first method is obviously the simpler of the two, but there are many applications where the second method is preferable. Hardening the surface may make it possible to use a metal that is lighter in weight, less expensive, or tougher and more ductile than a hard metal. Consequently, in many instances, a hard coating or surface is preferred because it allows use of a base material with optimum properties desired.

The purpose of this manual is to provide the designer with the basic data on hard surfaces that he needs for intelligent design. The manual discusses the various methods by which hard coatings can be obtained, giving particular attention to: the degree of hardness of each coating, the base metals that can be coated, the thickness of each coating and the wear properties of each coating.

Hard Facings

Hard facings can be applied to parts for wear resistance, corrosion resistance or heat resistance, but the object of most hard facings is to increase wear resistance.

Service performance of hard facing alloys cannot be compared on the basis of ordinary Rockwell or Brinell hardness, for it is primarily structure that determines their properties. It is important to distinguish between two kinds of hardness: 1) over-all hardness as determined by a Rockwell or Brinell test, and 2) microhardness, i.e., hardness of the structural constituents of an alloy. Rockwell hardnesses of most hard facing materials are no higher than those of heat treated, plain high carbon steel, yet these hard facings outwear high carbon steels from 2 to 20 times. Thus, it is evident that over-all hardness is not too indicative of the wear resistance of hard facing materials. However, the correlation between microhardness and wear resistance is much closer. Two methods of measuring microhardness are widely used; measurements obtained by these methods are expressed as Vickers Pyramid Numbers (VPN) and Knoop Numbers. By using suitable conversion scales, these readings can be converted to the more widely known Rockwell or Brinell values.

Classification of alloys

Hard facing materials are manufactured in a variety of forms, including welding rods, tube-rod composites, insert shapes, coated and bare electrodes, and powders or granules. There are hundreds of different hard facing alloys on the market today. It is extremely difficult and often misleading to group these alloys according to their hardness, structure or service use. However, a classification based on the chemical composition of the deposit (undiluted by the basis metal) has been found to be useful. A simplified version of this classification is contained in Table 1. (Detailed chemical compositions are contained in the Welding Handbook, Third Edition, p 869, and in American Welding Society Spec. A 513-56T.)

As shown, the first group of ferrous alloys includes the carbon steels, alloy steels with varying carbon contents and high speed steels. All of these grades are hardenable by heat treatment. Going from top to bottom, alloys in this group provide progressively greater hardness and corrosion and impact resistance. All but the highest levels of hardness and impact resistance can be obtained with these alloys. Their abrasion and corrosion resistance, however, is appreciably lower than that of some other compositions.

The second major group of ferrous alloys consists of the chromium, chromium-nickel and manganese steels and the high alloy irons. These alloys provide principally austenitic deposits (some of the straight chromium steels in this group, however, are ferritic in structure) which are hardenable by cold work and are not usually heat treated. Alloys in this group combine a fair degree of hardness with good impact and abrasion resistance that extends into elevated temperatures.

Of the nonferrous alloys, the high alloy materials based on chromium, cobalt and tungsten display the greatest corrosion resistance, together with good abrasion and impact resistance. Hardness of these alloys is less than that of the highly alloyed ferrous materials and carbide inserts.

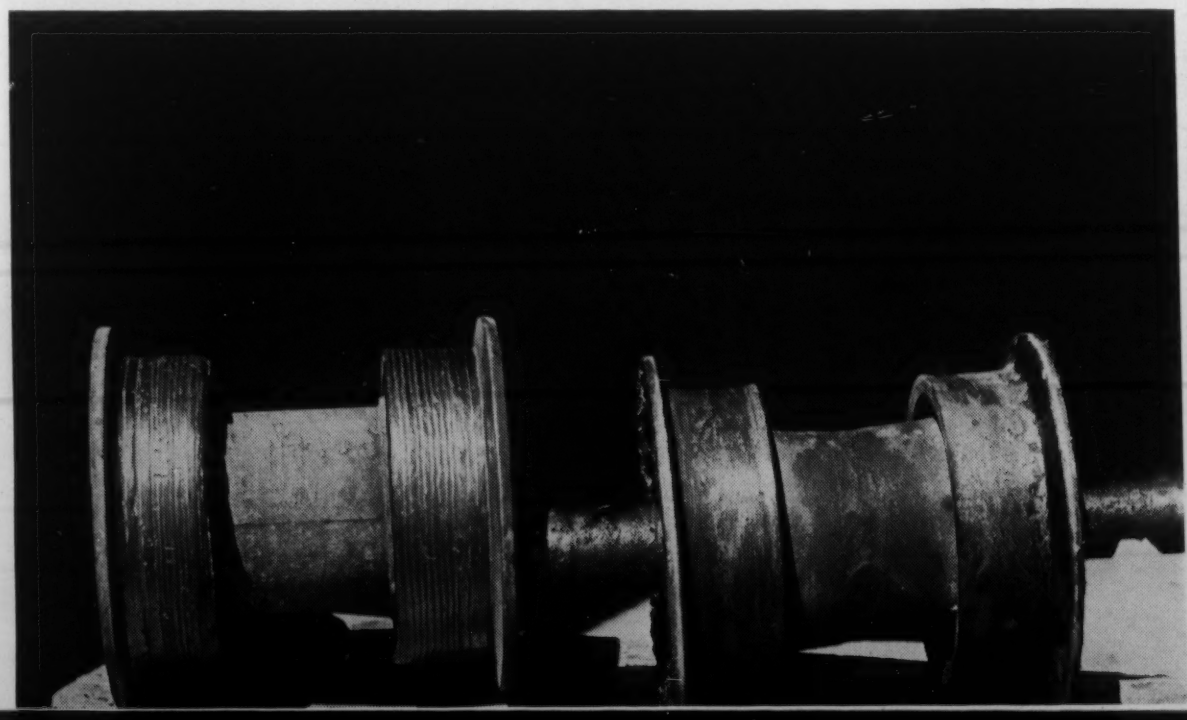
The tungsten carbides combine maximum hardness with excellent resistance to impact and corrosion. Despite their brittleness, the carbides have excellent resistance to fracture when backed up with steel.

The copper base alloys are intended primarily for soft surfacing applications such as bearing surfaces. Phosphor bronze provides a soft deposit of approxi-

TABLE 1—TYPES OF FACING ALLOYS HARD

FERROUS ALLOYS
Hardenable alloys
Carbon steels
Low, medium and high alloy steels
High speed steels
Austenitic steels
Chromium and chromium-nickel steels
High manganese steel
Austenitic irons (not usually heat treated)
High chromium iron
High alloy irons
NONFERROUS ALLOYS
Cobalt-base, medium and high carbon
Tungsten carbide
Copper-zinc alloys (brasses)
Copper-silicon bronzes
Copper-aluminum bronzes
Nickel-copper alloys
Nickel-chromium alloys
Nickel-base, chromium-tungsten-molybdenum alloys

Tractor rollers *before (right) and after (left) automatic hard facing. Smoothness of deposit eliminates finishing operation.* Stoody Co.



mately 70 Brinell. Aluminum bronze and silicon bronze alloys can provide deposits with hardnesses ranging from 115 to over 300 Brinell. In general, the nickel alloys possess excellent resistance to heat and corrosion with a fair degree of abrasion and impact resistance.

Basis metals

Practically all ferrous metals can be hard faced. With a few exceptions, nonferrous alloys cannot be hard faced because of their low melting points.

Low and medium carbon steels—Steels with up to 0.50% carbon in hot or cold rolled form or in the form of castings are especially suited to hard facing. Heat treatment is not required before or after welding.

High carbon and low alloy steels—With reasonable precautions to prevent cracking, carbon steels having as high as 1.10% carbon and 14% manganese can be successfully hard faced. It is usually preferable to hard face the material in an annealed or as-rolled condition. Hard facing procedure for low alloy steels is similar to that for carbon steels.

High speed steels—These are not generally recommended as a base for hard facings because of the occurrence of shrinkage cracks and strain checks. High speed steels that must be hard faced should be in the annealed state, and should be reheated and cooled slowly after welding.

High chromium (3 to 12%) steels—These steels are extremely susceptible to heat and must be carefully handled. Before facing, parts should be preheated to about 1200 F. Cooling after application should be retarded.

Stainless steels—These steels may be hard faced by either arc or gas welding methods and should generally be preheated. Properties of the particular type of stainless must be taken into account to avoid strains, brittleness or decreased corrosion resistance resulting from welding or preheating.

Cast irons—Gray and alloy cast irons present considerable difficulty in hard facing, but with proper care hard facing can be accomplished successfully. White or chilled iron can be easily hardened in small parts, but heat treatment is often necessary on large parts.

Nonferrous alloys—It is not advisable to hard face alloys with melting points below 2000 F. Because of their low melting point and high conductivity, copper, brass and bronze are hard faced with difficulty. Monel can be easily hard faced.

Surface finish, thickness

Smoothness of a hard facing depends upon the material and the welding method. Materials with the highest fluidity give the smoothest deposits. Thus, the nonferrous alloys can produce the smoothest and thinnest deposits.

Roughest finishes are obtained with tungsten carbide composites. Both the insert and rod forms of tungsten carbide give a rough surface. If the carbide particles are very fine and are completely submerged in the matrix alloy, the original finish may be quite smooth. In service, however, the softer matrix wears first and soon exposes the harder, rough carbide particles.

Thickness of hard facing deposits ranges from 1/16 to ¼ in., the proper thickness depending upon the specific application. Parts that require a build-up greater than ¼ in. are usually rebuilt before hard facing with a lower cost material, such as a low alloy steel. The hardness of such underlayers may be around 300 to 450 Brinell.

Where applicable, a mild steel filler rod or shape can serve as a base for the hard facing. In other cases inserts of the appropriate hard facing material itself may be more practical than building up a thick section.

Where an extremely thin layer is required, those alloys with high fluidity and low melting points are best. Some of the nickel-chromium-boron alloys wet the base metal so readily that a uniform deposit 1/32 in. thick can be obtained.

Haynes Stellite Co.

Rock crushing hammers *of manganese steel exhibit seven-fold increase in service life when hard faced with iron-chromium alloy.*

MAJOR TYPES OF HARD COATINGS AND SURFACES—A SUMMARY

Type of Coating	Method of Application	Basic Metals That Can Be Coated	Nature of Hard Surface	Usual Thickness Range	Hardness	Major Characteristics
Hard Facings	Hard alloys applied by variety of welding processes, including gas welding, metal arc welding and atomic hydrogen arc welding. Surface of metal is brought to melting point of hard facing alloy. Parts may require preheat from 700–1200 F	Practically all ferrous metals. Some high melting nonferrous alloys	Variety of ferrous and nonferrous alloys. See Table 1	1/16–1/4 in.	Wide range up to Rockwell A90, depending on alloy used	High hardness combined with varying degrees of resistance to abrasion, impact, corrosion and heat, depending on alloy used
Carburized Surfaces	Carbon in solid, liquid or gas form introduced into metal surface by heating both in contact at temperatures above the transformation range, generally 1450–1750 F	Carbon and alloy steels low enough in carbon content (<0.45%) to take up that element readily.	Case high in carbon	0.005–0.25 in.	Approx Rockwell C62 to C64	Most widely used diffusion coating. High strength and toughness in core can be combined with extreme surface hardness
Nitrided Surfaces	Nitrogen introduced into surface by heating metal in contact with ammonia or other nitrogeneous material, the temperature ranging from 930–1050 F	Primarily special nitriding steels. Also medium carbon steels containing chromium and molybdenum, stainless steels, some cast irons	Case containing nitrides of various alloying elements	0.005–0.030 in.	Approx Rockwell C63 to C64 for molybdenum steel, 15N92 for Type 416 stainless and Nitralloy 135	High wear resistance, retention of hardness at elevated temperatures. Good resistance to certain types of corrosion
Cyanided or Carbonitrided Surfaces	Carbon and nitrogen introduced into surface by heating metal in a liquid cyanide bath (cyaniding) or in a carbonacious and nitrogeneous (carbonitriding), the temperature ranging from 1200–1600 F	Same steels as used for carburizing	High carbon case containing nitrides	0.003–0.020 in.	Rockwell A80 to A81 for SAE 1010 steel	In general, same as for carburized cases
Siliconized Surfaces	Silicon introduced into surface by heating metal in contact with silicon carbide and chlorine at 1700–1850 F	Low carbon (<0.25%), low sulfur (<0.04%) steels	Alloy case containing up to 14% silicon	0.005–0.010 in.	Rockwell B80 to B85	High resistance to wear, heat and corrosion
Chromized Surfaces	Chromium introduced into surface by heating metal in contact with a chromium containing powdered compound at 1500–1900 F	Low and high carbon steels, many alloy steels, stainless steels, tool steels, cast iron, iron powder parts	High chromium stainless steel or chromium carbide, depending on metal composition	0.5 to 2 mil	1600–2300 Vickers for chromium carbide case	High resistance to wear, abrasion and corrosion
Flame Hardened Surfaces	Surface structure changed by heating surface only with oxyacetylene flame above transformation range, followed by quenching	Any steel that can be hardened by conventional methods, including medium carbon steels, gray cast iron, pearlitic malleable and nodular cast irons, alloy cast irons, hardenable stainless steels	Hardened surface structure. No change in chemical composition	0.06–0.25 in.	Max hardness depends on carbon content of base metal	High hardness, resistance to wear and abrasion
Induction Hardened Surfaces	Surface structure changed by heating surface only by means of electrical induction above transformation range followed by quenching	Medium carbon steels, gray cast iron, pearlitic malleable and nodular cast irons	Same as flame hardened surface	0.015–0.125 in.	Max hardness depends on carbon content of base metal	Same as for flame hardened surface
Chromium Plate	Electrodeposition of chromium	Iron, steel, copper, nickel, zinc, aluminum, magnesium, titanium, brass, etc.	Chromium	Approx 1 mil max	Up to 1000–1025 Brinell	High hardness combined with excellent corrosion resistance, low coefficient of friction, nongalling and nonwetting properties
Nickel Plate	Electrodeposition of nickel	Iron, steel, copper, zinc, aluminum, magnesium brass, etc.	Nickel	Up to 1/4 in.	150–800 Vickers	High wear and corrosion resistance
Rhodium Plate	Electrodeposition of rhodium	Most metals, including gold, silver and electrical contact materials	Rhodium	0.001 to 1 mil	540 to 640 Vickers (20-gm load)	High hardness and wear resistance combined with attractive appearance
Hard Anodic Coatings	Surface connected to metallic oxide or other inorganic compound by electrochemical process in which the metal is made the anode in an electrolyte	Most aluminum alloys (see text) and magnesium	Case consisting of oxides or other inorganic compounds of the base metal	Approx 1–5 mil	Difficult to assess by conventional methods. See text	Better resistance to abrasion, erosion and corrosion than base metal
Sprayed Coatings	Metal or ceramic layer applied by spraying molten or semimolten particles which fuse, cool and solidify on surface. Surface temperature ranges up to 800 F, depending on material sprayed and application method used	Most commonly used metals	Bronze, various irons and steels (see Table 7), molybdenum, aluminum oxide, zirconium oxide, zirconium silicate, tungsten carbide	Metals: up to 1/8 in. Ceramics: 0.005 to 0.050 in.	Up to 1350 Vickers for tungsten carbide	Extremely wide range of surface properties, depending on coating material

Diffusion Coatings and Heat Treated Surfaces

Diffusion and heat treatment methods of surface hardening are used principally on irons and steels.

The diffusion processes produce changes in the chemical composition of the surface layers and are usually followed by heat treatment. The common procedures discussed here increase carbon content (carburizing), nitrogen content (nitriding), carbon and nitrogen content (cyaniding and carbonitriding), silicon content (siliconizing) and chromium content (chromizing).

The heat treatment methods employ structural changes in the surface layers. Increase in hardness is achieved by quenching a hardenable steel from above the transformation range as in the usual heat treatment procedures. However, heat is applied to the surface so rapidly that only the surface layers are heated to the austenizing temperature. After quenching these layers are hardened, but the core remains in its original condition.

Selection of the optimum process for a given application depends on many factors. The stresses that must be sustained by the finished part are fundamental in determining the required core properties and case characteristics. For static compressive stresses, the case must have sufficient depth and must be backed with a core strong enough to resist surface deformation. If bending stresses are involved, some case hardness must be sacrificed and core properties must be modified to obtain optimum resistance. For resistance to abrasion, high case hardness with sufficient depth to give reasonable service life is necessary. Satisfactory functioning of the part also depends on such factors as metallurgical structure, graduation of structure and hardness from case to core, and condition and hardness of the surface. Selection is based to a large extent on experience with actual parts under service or simulated service conditions, and a study of parts that have functioned satisfactorily in service.

Carburizing

Carburizing has been defined by the ASTM as "a process of case hardening in which carbon is introduced into a solid iron-base alloy by heating above the transformation temperature range while in contact with a carbonaceous material which may be a solid, liquid or gas."

Steels for carburizing must be able to absorb carbon at a reasonable temperature and rate, be hardenable without excessive distortion, and be heat treatable to required core properties. If surface hardness is the principal requirement and core properties are not too critical, plain carbon steels are generally used. If high strength and toughness together with deep hardening are needed in the core, alloy steels must be used. In general, the process is limited to those steels low enough in carbon (below about 0.45%) to take up that element readily.

Of the plain carbon steels, the AISI 1000 and 1100 series are generally employed and the carbon content held to a maximum of 0.25%. Moderately alloyed steels containing up to 2% alloying elements are selected frequently for applications where oil hardening is desired. The more commonly used low alloy steels are AISI series 3100, 4000, 4100, 4600, 5100, 6100, 8000, 8600 and 8700. AISI 4615 is probably the most popular alloy carburizing grade. Carbon content may range up to 0.45%, but a limit of 0.25% is preferable for fine grained steels. Of the more highly alloyed steels, AISI series 2300, 2500, 3300, 4300, 4800 and 9300 are employed, with carbon content generally limited to a maximum of 0.25%.

A carburized steel has a duplex structure consisting of a high carbon case and a low carbon core. Since the addition of carbon to iron lowers the transformation range, the case can be hardened at a lower temperature than the core and a considerable variation of case and core properties can be obtained by using different heat treatments.

The principal methods of carburizing iron-base alloys are:

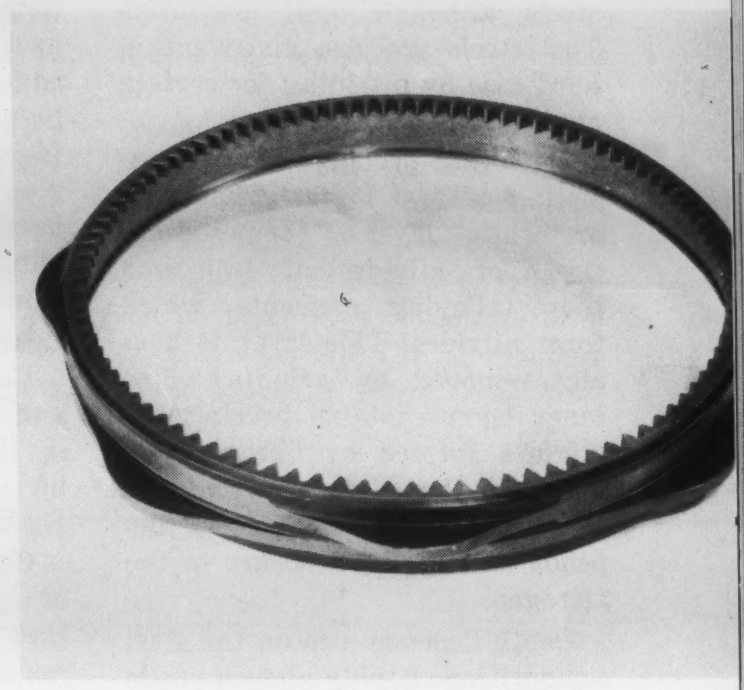
1. *Pack (box) carburizing*—The steel is placed in a box together with a solid carburizing compound. The box is sealed and heated to the required temperature. Because the heating rate is slow and it is impossible to raise the entire contents of the box uniformly to the carburizing temperature, warpage occurs and it is difficult to obtain uniform thin cases. The method is seldom used for cases less than 0.025 in. deep, the lower limit generally being about 0.040 in. It is also necessary to specify fairly liberal case depth tolerances, for it is difficult to hold less than 0.010 in. variation in depth of case throughout the box.

2. *Gas carburizing*—Steel is heated in contact with carbon monoxide and/or a hydrocarbon that is readily decomposed at the carburizing temperature. An important advantage over the pack method is that rate of flow can be adjusted to obtain the desired carbon content and depth of case. Other advantages include adaptability to large volume production and to small parts, and low labor costs.

3. *Liquid carburizing*—In this process the carburizing medium consists of cyanides together with an activating agent. Liquid carburizing is quite flexible since different case depths can be obtained in the same furnace by varying the carburizing cycle. Pieces can also be carburized selectively by immersing only the section to be carburized. Among other advantages are freedom from sooting and oxidation.

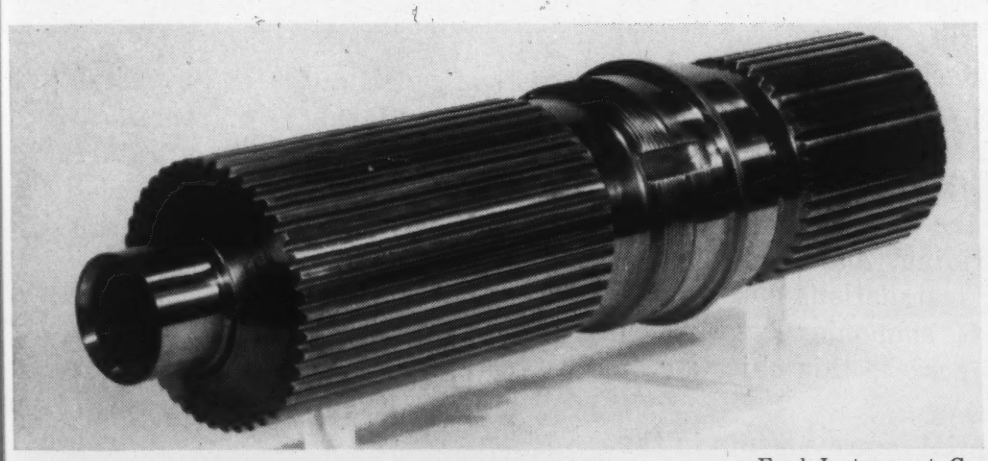
Nitriding

Nitriding is a means of case-hardening certain alloy steels by



Cam *of AMS 6260 steel is carburized and subsequently hardened and tempered for added wear resistance. Carburized cam at left is 1015 steel.*

Diffusion coatings are used on these parts



Ford Instrument Co.

Clutch shaft *of Nitralloy 135 is gas nitrided to produce a Rockwell 15N hardness of 92 to 93.*

Chromalloy Corp.

Thread guides *for textile machinery are chromized for extra wear resistance. Parts must resist severe abrasive action of nylon thread running at very high speeds.*

treating them with ammonia or other nitrogenous material. In the most widely used process, steel is exposed to gaseous ammonia at a temperature suitable for the formation of metallic nitrides.

Hardest cases are obtained with aluminum-bearing steels such as the Nitralloys. These are generally medium carbon steels that also contain chromium and molybdenum. For some applications, lower hardness is acceptable and steels containing no aluminum are used. Among such steels are the standard medium carbon steels containing chromium and molybdenum.

Stainless steels can also be case-hardened by nitriding. A proprietary process known as Malcomizing is widely used. Straight chromium steels are more readily nitrided than nickel-chromium

steels although both are used. Tool steels are also given a thin hard case by nitriding for certain applications.

Nitriding produces a case consisting of two layers. The outer or "white" layer is composed entirely of nitrides of iron and those alloying elements which form nitrides. This layer is usually removed by grinding. The inner layer contains precipitated nitrides formed by diffusion inward of the nitrogen from the white layer, and case depth depends on time of exposure to the nitrogen.

Depth depends also on the steel composition. Highly alloyed steels are penetrated less readily by nitrogen, and cases developed in stainless steels are shallower than those developed in the Nitralloys.

Hardness of the case depends on a number of factors. The lower the nitriding temperature, the harder is the useful case. Aluminum is the most effective element in promoting hardness. Cases in steels containing aluminum have hardness in the range of 1050 to 1150 DPN, excepting those steels containing nickel (Nitralloy N) whose hardness ranges from 950 to 1050 DPN. Steels containing no aluminum have cases of lower hardness, generally in the range of 600 to 900 DPN.

Wear resistance is an outstanding characteristic of the nitrided case and is responsible for its selection in most applications. The hardness of a nitrided case is unaffected by heating to temperatures below the original nitriding temperature. Substantial hardness is retained to at least 1150 F, whereas a carburized case begins to lose its hardness at relatively low temperatures. Fatigue resistance is also a valuable feature. Tool marks and surface scratches have little effect on the fatigue properties of nitrided steels and notches formed before nitriding do not reduce fatigue strength to an appreciable degree.

Since nitriding is performed at relatively low temperatures and no quenching is required, distortion is reduced to a minimum. Some growth occurs, but if allowance is made for growth, parts can be finished to close tolerances before nitriding—another advantage over carburizing. Some complex parts which cannot be case-hardened satisfactorily by carburizing can be nitrided without difficulty.

Cyaniding, carbonitriding

Cases containing both carbon and nitrogen are produced both in liquid baths (cyaniding) and by the use of gas atmospheres (carbonitriding).

Generally, the carbon content of cyanided cases is lower than that produced in carburizing and ranges from about 0.5 to 0.8%. However, the case also contains up to about 0.5% nitrogen and, consequently, file hard cases can be obtained on quenching in spite of the relatively low carbon content. Cases produced by carbonitriding are shallow—from 0.003 to 0.020 in.—and are similar to those obtained in cyaniding under similar conditions.

Since nitrogen increases the hardenability of steel, lower cost carbon steels can be substituted for alloy steels if the properties required of the core permit. It is reported that uniformity of hardness of the case is improved by carbonitriding, and in some carburizing installations small quantities of ammonia have been added to achieve this objective.

Siliconizing

Substantial improvements in the wear resistance and hardness of steel and iron parts can be obtained by impregnation with silicon to form a case containing about 14% silicon. The most wear resistant cases are formed on low carbon, low sulfur steels. High carbon, low sulfur steels can also be impregnated satisfactorily, although treatment time is liable to be somewhat longer. Treatment of SAE 1045 steel, for example, requires about twice as much time as a low carbon steel for a given case depth.

In general, carbon and sulfur contents should be below 0.25 and 0.04%, respectively. Most alloying elements have an adverse effect on case properties. For this reason, SAE 1015 or 1020 steels are preferred. Typical properties of SAE 1015 steel before and after siliconizing are as follows (from ASM Metals Handbook):

	Untreated	Siliconized
Elast Limit, psi	37,750	37,900
Ult Str, psi	60,550	51,400
Elong in 2 in., %	38.5	19.5

White and malleable iron can be siliconized, but because of high sulfur content their cases are usually less satisfactory than those obtained on low carbon steels. Siliconizing of gray irons is not recommended due to swelling and formation of a relatively soft and porous case.

Basically, siliconizing consists of exposure to silicon carbide and chlorine at temperatures of about 1700 to 1850 F. Effects of all previous heat treatment are destroyed during impregnation, and properties of the case cannot be changed by subsequent heat treatment; however, the core may be subsequently heat treated by any method consistent with the metal.

Case depth can vary from 0.005 to 0.010 in. The case is rather brittle and its hardness varies from Rockwell B80 to B85. It can be ground, but not machined or cut with a hacksaw. Because of the uniform silicon content in the outer layer, the case can be ground to a considerable depth without damage.

Depending on the thickness of both case and section, parts swell from 0.001 to 0.005 in. during treatment. Distortion during treatment can be minimized if strains are removed by annealing prior to treatment. Sections under ⅛ in. should be avoided as they are likely to bend during treatment. Very thin sections are brittle because of their tendency to be siliconized all the way through. Sharp corners should be avoided wherever possible.

An allowance of 0.010 in. extra stock should be made wherever close tolerances or smooth surfaces are required. Threaded parts must be threaded undersize

to allow for slight swell, or threaded after treatment, the case being first removed in the thread area.

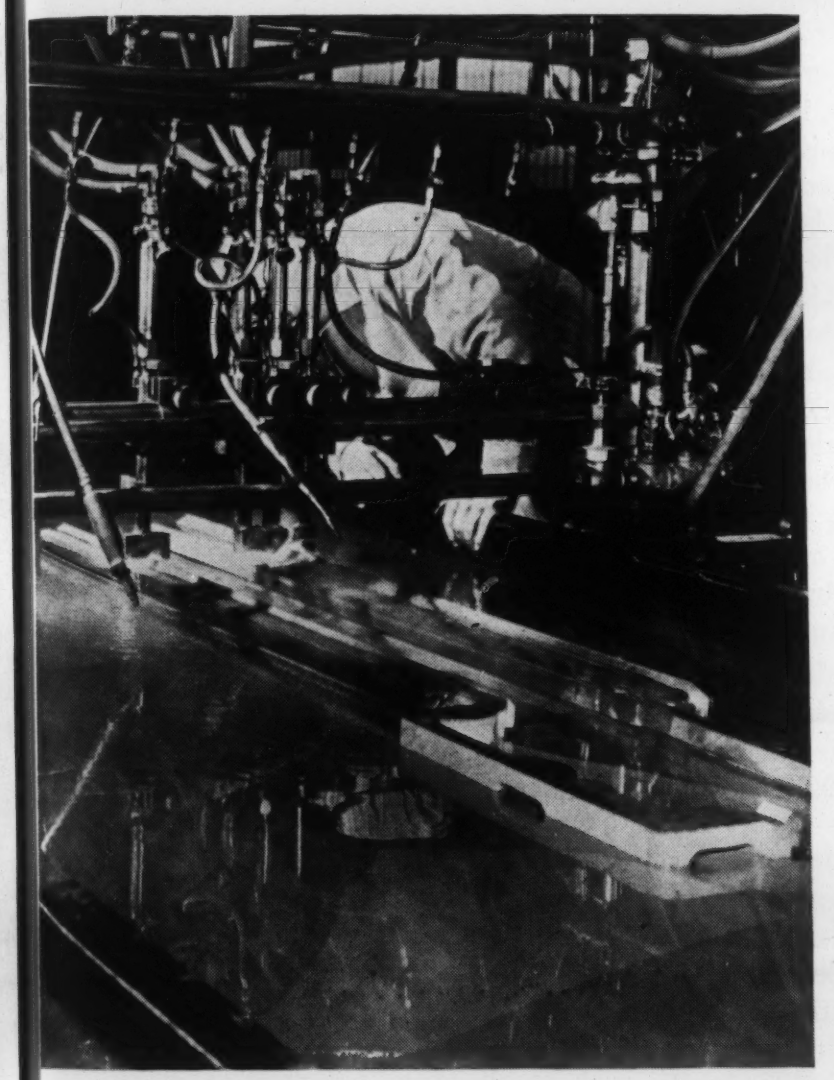
Siliconized surfaces are virtually nongalling and stand up quite well under frictional wear. They are not recommended for high velocity abrasion, such as sandblasting. The case is especially effective in resisting the combined effects of wear and corrosion. Siliconized parts heated to 250 to 300 F in a heavy oil subsequent to grinding are capable of functioning as self-lubricating bearings. Parts treated in this way have shown a five fold increase in wear resistance over plain siliconized parts.

Chromizing

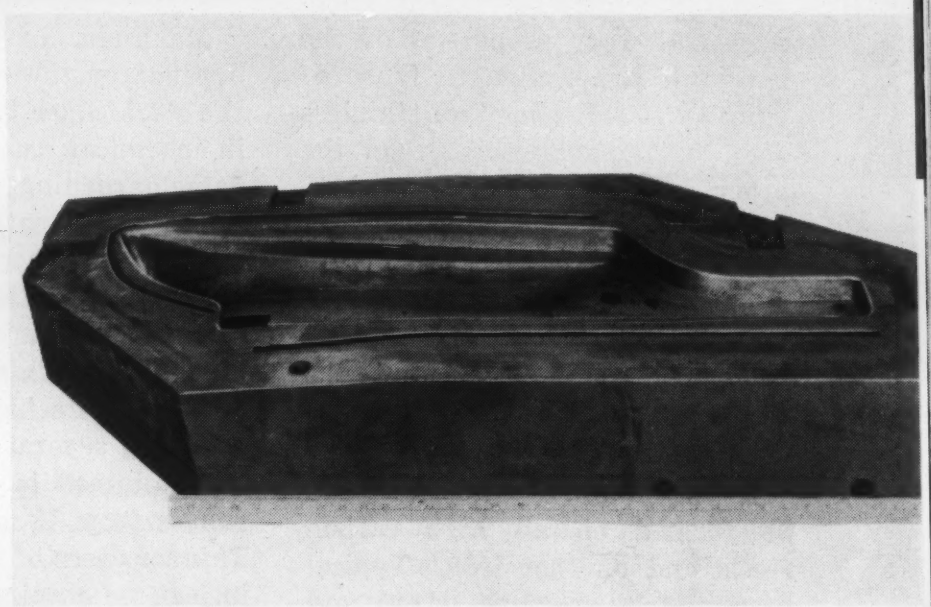
Chromizing has been used in a number of applications to increase the hardness and wear resistance of low carbon steels and many types of alloy steels, high chromium and other stainless steels, tool steels, cast iron and iron powder parts.

Various methods for impregnating steel with chromium have been developed. The Chromalloy process uses a reaction between

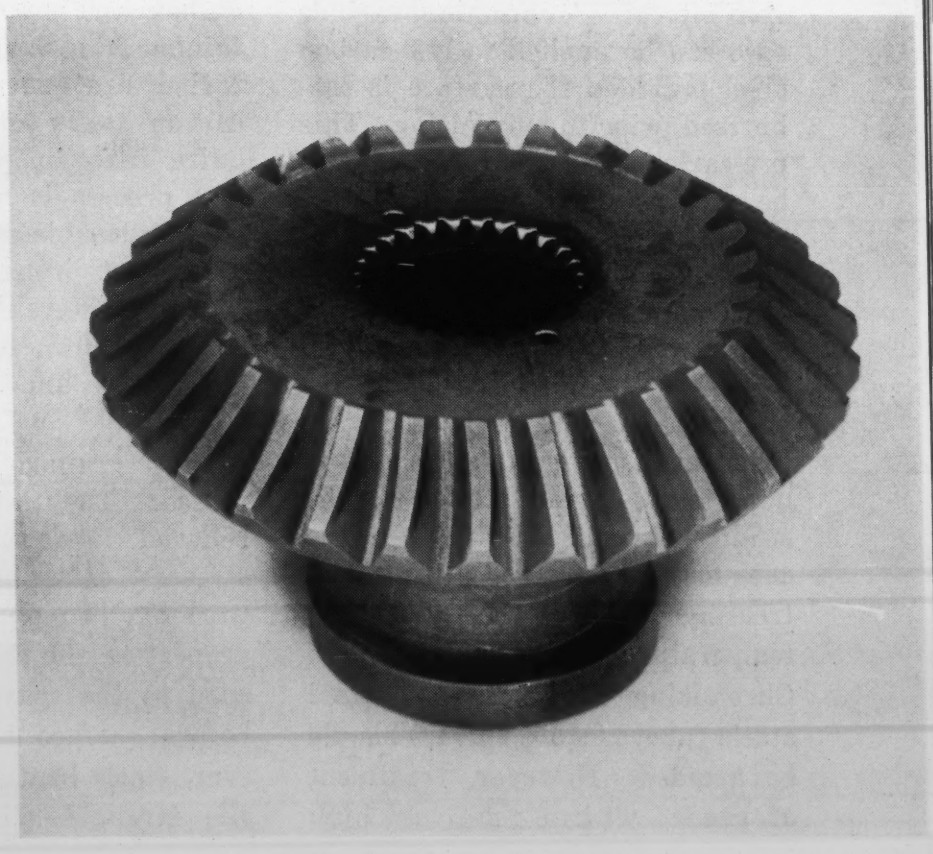
Heat treated surfaces are used on these parts



Lathe ways *are flame hardened for increased life.*



Cast iron stamping die *has hardness of Rockwell C55 to C60 after flame hardening.*



Steel gear *tempered after induction hardening has case hardness of Rockwell C42.*

a gaseous chromium compound and iron as a means of exchanging iron atoms for chromium at the metal surface. The parts are packed in a proprietary powdered compound containing chromium and heated to 1500 to 1900 F.

A gaseous chromium compound reacts with the ferrous surface, substituting chromium for iron atoms. As a result, the surface is transformed into either high chromium stainless steel or chromium carbide, depending on the composition of the metal and the treatment selected.

When processing conditions are adjusted so that only high-chromium-iron alloy is formed, hardness and wear properties of the case are comparable to those of fully annealed chromium stainless steel of the 400 series. On the other hand, formation of chromium carbide (usually between 0.005 to 0.002 in. thick) results in a much harder case. Microhardness measurements of 1600 to 2300 Vickers indicate that the chromium carbide is nearly as hard as tungsten carbide.

A chromium carbide case can be formed on all high carbon steels and on cast iron. Typical base metals are 1095, 4140 and 52100 steels; 5 and 12% chromium tool steels; ductile and gray iron; and sintered 1% graphite-iron mixture. A chromium carbide case can be applied to low carbon steel provided the surface is carburized prior to chromizing. This pre-carburizing treatment can also be used on various carbon-free alloys, such as 18-8 stainless steel and Hastelloy B, which may be specified for their high temperature strength or other properties. Type 18-4-1 high-speed steels are not recommended as base metals if subsequent heat treatment is necessary. These steels can be readily chromized; however, the case may be damaged during heat treatment when the quenching temperature is above 2200 F. Chromizing of highly sulfurized steels (above 0.15% sulfur) should be avoided. However, treatment of grades with a relatively high manganese content (1%), such as 1137, is acceptable.

Flame hardening

The oxyacetylene flame is generally used for flame hardening. Its temperature, which approaches 6000 F, quickly raises the surface of the steel to a temperature high enough to permit hardening by quenching. Propane, natural gas or mixed city gas are sometimes used instead of acetylene.

Flame hardening can be used on any steel that can be hardened by conventional methods. Depth of the hardened zone can be controlled to a certain extent by adjusting flame intensity and heating time or speed of travel.

Maximum hardness obtainable depends on the carbon content of the steel. Since there is no change in chemical composition during flame hardening, there is no sharp line of demarcation between case and core. There is instead a gradual reduction in hardness away from the hardened surface until the original hardness is reached. The hardened region is generally several times as deep as that obtained in carburizing, and ranges from ⅛ to ¼ in. in depth. Thinner cases of the order of 1/16 in. can be obtained by increasing heating and quenching speed.

Flame hardening is applicable to all hardenable steels. However, carbon and low alloy steels containing from 0.35 to 0.60 or 0.70% carbon are generally used. High carbon steels and tool steels require care to prevent cracking. The process is applicable also to the hardenable stainless steels, to gray cast irons with combined carbon preferably in the range 0.50 to 0.80%, to pearlitic malleable irons and to nodular cast irons.

Fine grained steels are preferred. They should be stress relieved before hardening if stresses exist because of prior working. To obtain special core properties, the steels can be hardened in the conventional manner before surface hardening. However, steels heat treated to a tensile strength above 125,000 psi may crack if flame hardened.

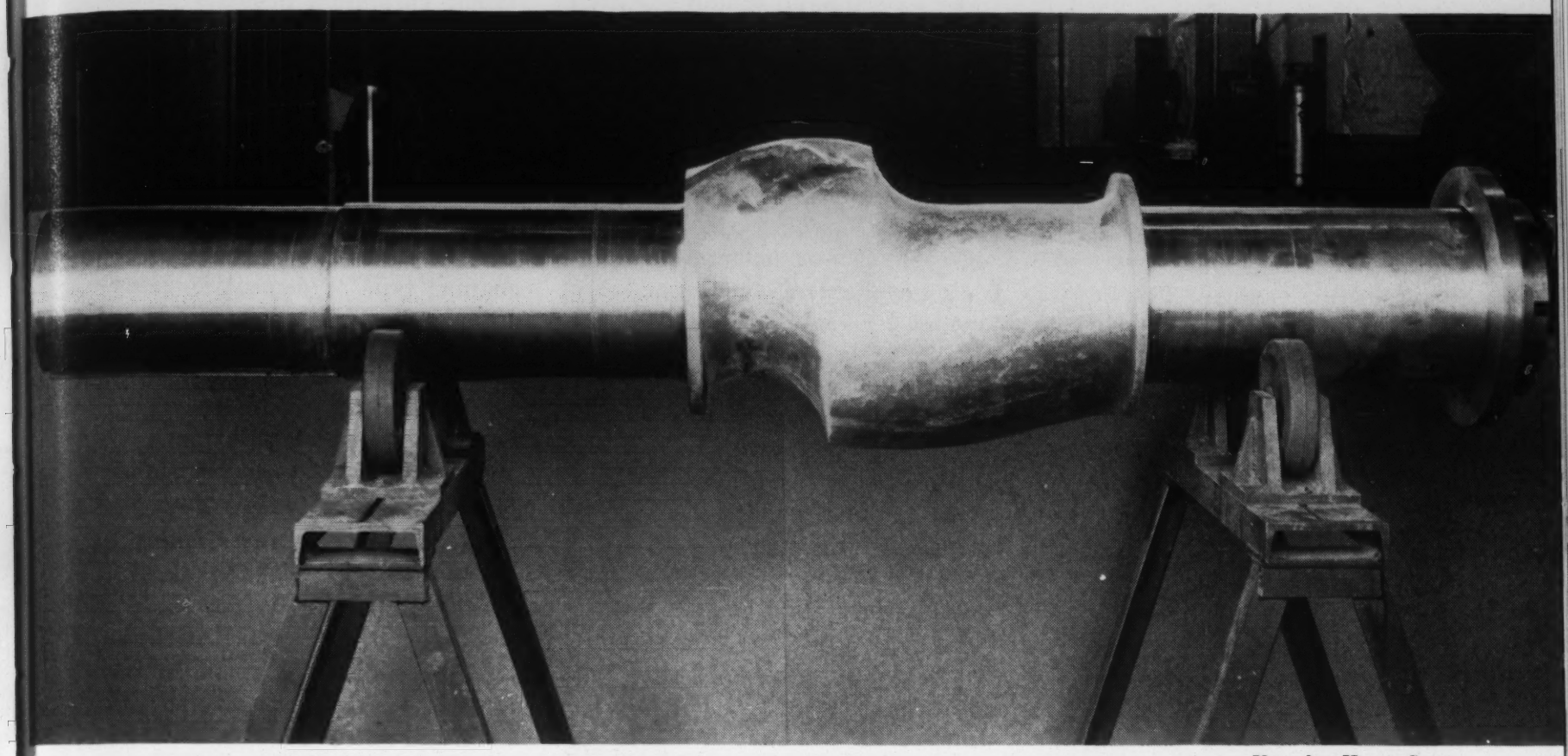
Among the advantages of oxyacetylene flame hardening are adaptability and portability. The equipment can be taken to the job and adjusted to treat only the area which requires hardening. Parts too large to be placed in a furnace can be handled easily and quickly with the torch. The equipment is ready for almost instant use at any time. Another advantage is the ability to treat components after surface finishing since there is little scaling, decarburization or distortion.

Induction hardening

Induction hardening utilizes localized heating produced by currents induced in a rapidly changing magnetic field. Since the surface layer is heated almost instantaneously to a depth that is inversely proportional to the square root of the frequency, high frequency heating is generally employed for surface hardening. Time of heating is important if a shallow hardened zone is to be formed, since heat tends to flow toward the center by conduction.

The case obtained by induction hardening is similar to that obtained in flame hardening. However, thinner cases can be obtained because of the greater speed of heating. It has been stated that, using minimum heating times, a case depth of 0.040 in. is obtainable with a frequency of 10 kc, whereas a depth of 0.018 in. can be obtained by increasing the frequency to 120 kc.

Steels used for induction hardening are similar to those used for flame hardening. Plain carbon steels of medium carbon content are used for most applications, particularly for production of thin cases. Maximum surface hardness obtainable depends on the carbon content. Alloy steels can also be induction hardened and are needed particularly for deep cases. Low alloy steels are readily induction hardened, but highly alloyed steels are more sluggish and may require an increase in temperature to achieve the structure needed for satisfactory hardening.



Van der Horst Corp.

Helix rotor *of Banbury mixer is chromium plated for increased wear resistance during rubber processing.*

Electroplated Coatings

Hard chromium plate

The success of chromium plate in industrial or nondecorative applications can be attributed to its unique combination of hardness, corrosion resistance, low coefficient of friction, and nongalling and nonwetting properties. In general, the benefit of the full hardness of chromium deposits cannot be obtained unless the coating is applied on a sufficiently hard base metal, such as hardened steel, and to a satisfactory thickness. The hardness of most industrial bright chromium deposits is about 1000 to 1025 Brinell. When heated to 2200 F all chromium deposits decrease in hardness to about 200 Brinell.

Some suggested values for base metal hardness and thicknesses of chromium to be applied for various applications are listed in Table 2. In most applications the optimum deposit thickness and base metal hardness is established empirically and on the basis of past performance. If a high measure of corrosion resistance is required in addition to wear resistance, relatively thick deposits of at least several mils should be applied. Undercoats of nickel or copper are also sometimes used for added corrosion resistance. Comparatively thin deposits of Crack-Free chromium (the Unichrome Process) have been found to give high corrosion resistance when plated directly on steel. Although the hardness of these deposits is only about 600 Brinell, they have been found to possess higher wear resistance in some applications than regular hard chromium plate.

Hard chromium plate is particularly useful because of its low coefficient of friction. Whereas the coefficient for hardened steel sliding on cast iron is 0.22, the coefficient for chromium plated steel sliding on cast iron is only 0.06. The low friction coefficient and other desirable surface properties of chromium plate are usually realized only on relatively smooth surfaces. Sometimes a bright deposit is applied to a smooth surface and used as is; however, deposits are frequently ground or lapped to size to achieve the optimum in surface properties. By careful treatment it is possible to plate to size within very close limits.

A number of investigators have reported the tendency of hard chromium deposits to reduce the fatigue strength of steel. This effect has been lessened to some extent by use of the new SRHS (self-regulating, high speed) chromium baths which produce deposits with less internal stress.

TABLE 2—RECOMMENDATIONS FOR HARD CHROMIUM ELECTROPLATES

Application	Steel Hardness, Rockwell C	Chromium Thk, mil
Drills	62-64	0.05-0.5
Reamers	62-64	0.1-0.5
Burnishing Bars	60-62	0.5-3
Drawing Plugs, Mandrels	60-62	1.5-8
Drawing Dies	62 inside, 45 outside	0.5-8
Plastic Molds	55-60	0.2-2
Gages	48-58	0.1-1.5
Pump Shafts	55-62	0.5-3
Rolls, Drums	—	0.25-12
Hydraulic Rams	—	0.5-4
Printing Plates (engraved steel)	—	0.2-0.5

These baths are also claimed to possess advantages in speed, hardness, brightness, smoothness, adhesion, plating range and covering power over ordinary plating solutions.

Surface hardness values ranging from Rockwell C70 to 72 are claimed for chromium alloy coatings deposited by the proprietary Electrolizing process. Deposits have been successfully applied to all ferrous and nonferrous metals with the exception of titanium and magnesium. Depending on service requirements, deposits can vary from 0.025 to 0.5 mil. Because of the precise control maintained during deposition it is claimed that deposits can be held to tolerances of 0.025 mil.

Applications of hard chromium plate are quite extensive. Some principal applications are gages, tools, and machine tool parts—both new parts and worn parts to be salvaged. Taps, drills, saws, milling cutters and burnishing tools have also been successfully plated. Molds for plastics and rubber are plated to reduce wear and sticking and to improve product appearance. Gun barrels, pump shafts, engine cylinders, drawing dies, calender rolls and engraving dies are other examples.

Porous chromium plate

This type of plate is essentially a hard chromium plate containing carefully controlled pits or channels designed to improve the lubricating properties of engine cylinder bores and other bearing surfaces. Beneath its outer surface the plate is no more porous than ordinary hard chromium plate.

Porous chromium plate consists of three principal types. The "mechanical" type is produced by hard chromium plating and subsequently polishing a roughened, cut or engraved basis metal; the polished tops of the grains form the bearing surfaces and the depressions between the grains hold the lubricating oil. The other two types of porous plate, referred to as the pit and channel types, are produced by chemical or electrochemical etching of the chromium deposit. The plating conditions are controlled so as to produce latent chromium deposits predisposed to the development of a particular size and type of network pattern during etching.

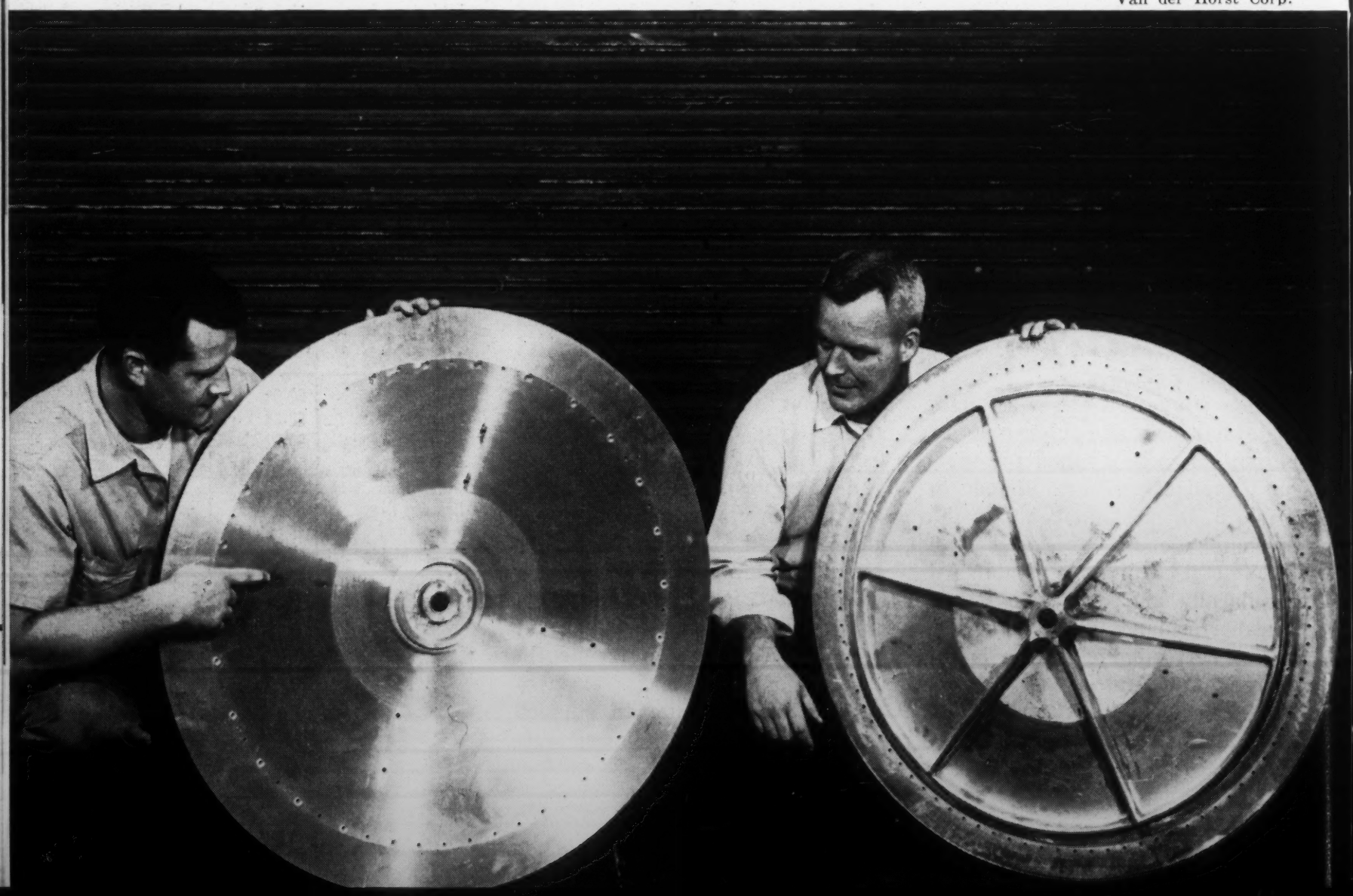
The pit or pocket type of porous plate is generally used on diesel engine cylinders and industrial gasoline and gas engines, pumps and compressors. The channel type of deposit is generally used on aircraft cylinders. Thickness and porosity of both types of deposits depends entirely on the size and type of engine. Depending on the application, coatings may range in thickness from 0.003 to 0.015 in.

Chromium plate on light metals

The combination of abrasion resistance and light weight has led to a number of applications for hard chromium plate on aluminum, titanium and magnesium.

Aluminum — Successful chromium plating of aluminum depends to a marked degree on pretreatment of the base metal. For successful plating the natural oxide film must be removed or modified, as it prevents good adhesion between the electrodeposited coat-

Aluminum sorting wheels *of capping machine are chromium plated to resist wear in handling plastics bottle caps.*
Van der Horst Corp.



ing and the basis metal. Also, certain microstituents that may react in the plating operation must be removed from the metal surface.

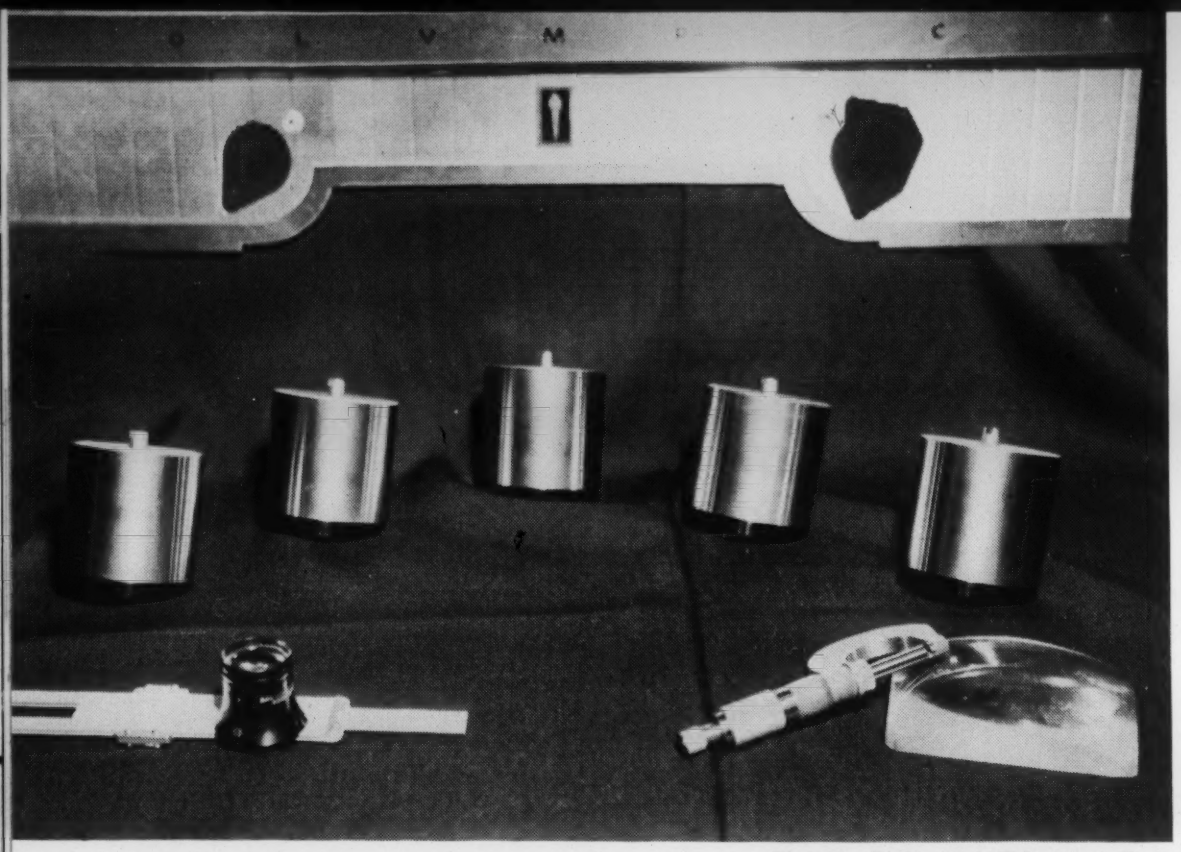
The zinc immersion coating process is by far the most common method of plating aluminum. Essentially, the process replaces the natural oxide skin on the aluminum with a thin zinc coating and prepares it for subsequent electroplating. Although the process requires more baths and more steps than most commercial plating processes, it is not too difficult to control and can be used, with suitable modifications, for all commercial cast and wrought aluminum alloys. A copper strike is usually applied over the zinc immersion layer before the chromium is deposited; however, if the proper plating techniques are used this intermediate step can sometimes be eliminated.

The wet blasting process is a comparatively new process which has been developed to electroplate chromium directly on aluminum with no intermediate coatings. Wrought, as well as sand and die casting alloys, can be plated. This process has only two steps: wet blasting and chromium plating. Aluminum is wet blasted with an abrasive suspended in water which removes the dirt and natural oxide coating from the surface. The abrasive action of the blasting particles roughens the surface, increases its area and promotes bonding between the basis metal and the plate. The resulting matte surface of the aluminum produces a dull, rather than a bright, chromium plate. The cost of chromium plating by this method is equal to or less than the cost of chromium plating steel by conventional processes.

Thickness of coatings produced by these two methods ranges from about 1 to 5 mils. In general, the hardness range of hard chromium plate on aluminum is about the same as that on other metals. Chromium plate can be applied to any aluminum alloy; however, it has been reported that alloys with

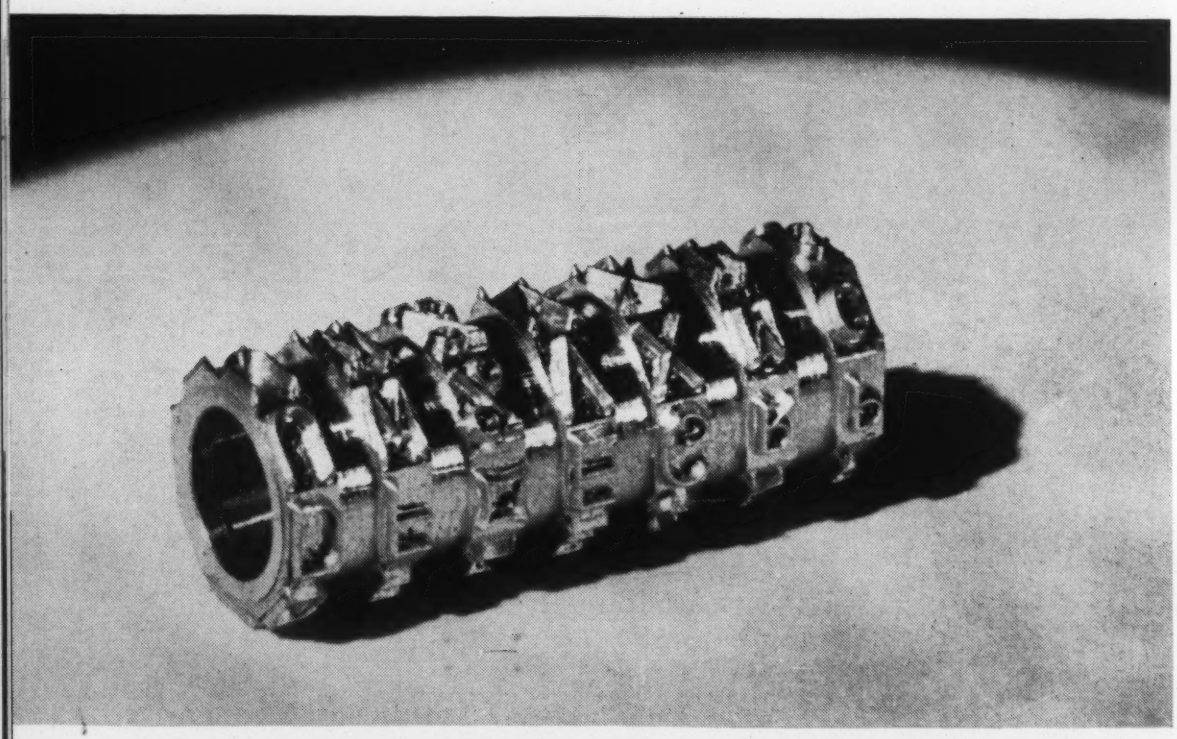
Van der Horst Corp.

Diesel engine cylinder *is restored to original design dimensions with porous chromium plate.*



Olympic Radio and Television Corp.

Aluminum capstans *for recording equipment are given chromium plate by Hardalume process for increased wear resistance.*



Tabulating machine impact roll *of 2024 aluminum plated with chromium has made over 18 million impressions without failure. Old stainless steel roll was discarded because of loss of clarity after 8 million impressions.*

Grooves of aluminum piston *are nickel plated by electroless process.*

Curtiss-Wright Corp.

a high magnesium content are more difficult to electroplate than the other alloys. Typical applications include engine cylinders and pistons, aircraft landing gear struts, guided missile and radar parts, plastics and rubber molds and printing plates.

In recent months a new method of depositing hard, ductile chromium plate on aluminum and titanium has been announced by Tiarco Corp. With this method deposits from 0.002 to 0.030 in. thick are applied directly to the basis metal after suitable surface preparation. For aluminum a three-step process (Hardalume) is used. The first step prevents oxidation of the cleaned surface by passivating the metal. The second step reactivates the surface during deposition of a bonding coat of chromium, and the third step deposits hard chromium to the required thickness. Hardness of the chromium deposit averages Rockwell C72 but runs as high as C80. The deposit is claimed to be 15% denser than conventional hard chromium coatings and is quite ductile.

Titanium—Prior to the application of the chromium plate to titanium, parts are cleaned, then immersed in a special surface activating bath (the Baylig process). The parts are then plated in a modified hard chromium plating solution.

One of the principal advantages gained by applying a chromium plate to titanium is the reduction in friction. Coefficients of friction for a number of metal-to-metal combinations are listed in Table 3. The frictional coefficient of titanium on Babbitt is about three times as high as steel on Babbitt, whereas chromium plated titanium has the same coefficient of friction as chromium plated steel against similar surfaces.

Seizing and galling of titanium have been so severe that applications involving sliding contact have not been successful. Hard chromium plating has overcome this problem satisfactorily. Pistons produced from titanium alloy 150A and chromium plated by the

Baylig process have been employed in an experimental weapon. Hard chromium plated titanium gears have also been used successfully.

Magnesium—In general, many of the applications of chromium plated magnesium are similar to those of plated aluminum. The most successful method of plating magnesium, developed by the Dow Chemical Co., consists of the application of an immersion zinc coating (about 0.0001 in. thick), followed by a copper strike and then chromium plating in a standard bath.

Adhesion of deposits laid down by the zinc immersion process is reported to be good. Heating affects adhesion on castings more than on wrought products. There is no lifting or blistering of deposits on wrought magnesium up to the melting point of the metal (1100 to 1200 F). On castings, electroplates may fail in adhesion above 450 F. Plated parts can be hammered and bent without failure. Under mechanical wear, heavy chromium plates (0.005 in.) have shown no tendency to peel. Abrasion resistance of chromium deposits measured with a Taber Abraser (CS-10 wheel, 1-gm load) is about 200 cycles.

Applications of chromium plate on magnesium are numerous and include machine parts, engine pistons, and printing plates and cylinders. In one application, a 0.0002-in. hard chromium plate increased the average life of magnesium printing plates from 500,000 impressions to 33,000,000 impressions.

TABLE 3—FRICTION COEFFICIENTS OF VARIOUS METALS

Metal Combination	Coef of Static Friction	Coef of Sliding Friction
Titanium on Babbitt	0.67 (approx)	0.60 (approx)
Steel on Babbitt	0.25	0.20
Steel on Chromium Plated Steel	0.17	0.16
Chromium Plated Steel on Babbitt	0.15	0.13
Chromium Plated Steel on Chromium Plated Steel	0.14	0.12
Chromium Plated Steel on Chromium Plated Titanium	0.14	0.12

TABLE 4—TYPICAL PROPERTIES OF NICKEL DEPOSITS

Property \ Type of Bath	Group I—Watts and Fluoborate		Group II—Nickel Chloride		Group III—Bright and Ammoniacal	
	Avg	Range	Avg	Range	Avg	Range
Vickers Hardness	192	140-400	270	200-390	467	350-820
Tensile Strength, 1000 psi	78	50-115	108	90-150	183	140-220
Elongation, %	19	2-31	9	4-17	3	1-5
Electrical Resistivity, micro ohm-cm	8.3	7.5-11	8.7	8.5-11	12.2	8.5-36

Nickel plates

Electroplated nickel coatings are extensively applied to steel, aluminum, magnesium, zinc, brass and other metals to increase their wear resistance, protect them from corrosion and enhance their decorative appeal. Bright nickel plates are widely used, mostly as an undercoat for chromium, although the bright nickel surface itself is sufficiently serviceable for many applications.

In many cases heavy nickel plates can be applied at lower cost and with better coverage than chromium. The better throwing power compared to chromium plating solutions is an advantage in plating parts with recesses and sheltered areas. Though not as hard as chromium, nickel deposits are sufficiently hard for many applications. The nickel deposits can be machined and buffed, whereas it is usually necessary to grind hard chromium deposits. Nickel deposits up to ¼ in. have been used to build up worn parts. In some applications heavy supporting layers of nickel are plated with chromium for greater wear resistance.

Nickel plate can be deposited from a number of different acid baths. Properties of the deposits can be changed considerably by adjusting the bath formulation. These baths may be divided into three distinct but not sharply defined groups. Group I includes the Watts type and the fluoborate baths. Group II are the baths containing only nickel chloride or nickel chloride combined with smaller contents of nickel sulfate or nickel acetate. Group III are the bright nickel baths and the alkaline baths with an excess of ammonia. The important physical properties of these three groups of nickel deposits are listed in Table 4. These data show that hardness, tensile strength and electrical resistivity tend to increase in going from Group I to Group III.

Because it is closely related to the tensile strength and ductility of a deposit, hardness is a convenient way to characterize a deposit. Nickel coatings can be obtained with hardness from 150 to 800 Vickers, depending on the conditions of deposition. Tensile strength varies from 50,000 to 200,000 psi and elongation from 5 to 35%.

Hard nickel deposits tend to soften when subjected to temperatures of 500 F or higher. The effects of temperature and time of exposure on the hardness of deposits are listed in Table 5. From these data it is evident that nickel deposits retain hardness in the range of 300 to 450 Vickers at temperatures below 500 F.

In many applications electroless nickel plates have proved superior to electroplated nickel. Hardness of two of the principal proprietary coatings ranges from about 450 to 600 Vickers. Among the advantages claimed for electroless nickel plate are: 1) it can be used

Dow Chemical Co.

Magnesium printing plates *plated with chromium are given 10- to 20-fold increase in printing life.*

on large parts that would be impractical to electroplate, 2) it can be obtained on surfaces that are inaccessible to electroplating, 3) it is highly uniform in thickness, 4) it is more wear resistant than conventional electroplates, and 5) its hardness can be increased by a short heat treatment. Chief limitations of these coatings are their high brittleness.

TABLE 5—EFFECT OF TEMPERATURE ON HARDNESS OF NICKEL DEPOSITS

Temp, F	Time, hr	Vickers Hardness	
		Initial	Final
400	18	325	295
	1 wk	325	295
500	18	325	295
	24	470	400-450
600	4	475	222
	4	445	380

Rhodium plates

Rhodium plate is widely used to provide a wear resistant, brilliant white, nontarnishing surface for jewelry. Because of the thin films usually encountered it is difficult to assign a definite hardness to the material. Hardness values of 540 to 640 Vickers (20-gm load), however, have been measured. Hardness of rhodium plate increases as thickness of the plate is increased. Very heavy plates on the order of 0.001 in. or more have shown values higher than hard chromium or even some carbides. Wear resistance of plates 0.01 mil or less in thickness seems to be about midway between that of nickel and chromium. Due to the metal's high wear resistance, extremely thin coatings—in the range from 0.001 to 0.005 mil—can often be applied.

The hardness and wear resistance of rhodium have been used to advantage on light reflectors. Many conventional surfaces with high reflectivity are incapable of withstanding the wear resulting from routine wiping off of oil films, paint spray and dust.

Its wear resistance, combined with its freedom from corrosion and high conductivity, also makes rhodium extremely valuable for electrical contacts. Rhodium plated slip rings and commutators exhibit very little wear after extended service. Depending on the application, thickness of the rhodium plate on electrical contacts ranges from 0.005 to 0.1 mil. Light duty contacts are frequently plated with 0.0015 mil of rhodium over 0.5 mil of silver.

Anodic Coatings

Hard coatings for aluminum

Anodizing is an electrochemical method that converts the surface of a metal to an oxide when the metal is made the anode in an electrolyte. The characteristics of these anodic coatings can be varied widely by adjusting the electrolyte and the operating conditions. Hard anodized coatings, produced by various proprietary techniques, are particularly valuable where high resistance to abrasion, erosion and corrosion combined with light weight is required.

Because of their greater thickness (0.001 to 0.005 in.) and density, these coatings can carry greater loads and have higher resistance to scratching and indentation type abrasion than the conventional thinner anodic coatings. Where resistance to rubbing or erosion type wear is required, coatings known as Alumilite 225, 226, 725 and 726 and the Martin Hard Coating (MHC) are available. Alumilite 225 and 226 coatings are for wrought alloys, whereas the 725 and 726 coatings are for cast alloys. In general, an allowance of 50% of coating thickness should be made for increase in dimensions.

Hard anodic coatings can be applied to all aluminum alloys, but certain alloys respond to anodizing better than others. Care must be taken in anodizing casting alloys, as these alloys usually contain appreciable amounts of silicon; alloys with more than 7% silicon do not respond satisfactorily. Also, alloys with a high copper and silicon content will not produce dense coatings of uniform thickness. Coatings can be formed on such wrought alloys as 2011, 2014, 2017 and 2024, but operating conditions are critical and the coatings are not as resistant to abrasion as coatings formed on alloys such as 1100, 3003, 5052, 6061 and 7075. In general, coatings formed on castings are not as smooth as those obtained on wrought products.

It is difficult to measure the hardness of hard anodic coatings by conventional penetration tests. It has been reported that after 50,000 cycles on the Taber Abraser, a 2-mil MHC coating showed only about half as much wear as the surface of a case-hardened steel. In general, these coatings have greater resistance to rubbing abrasion than to blast abrasion. However, the hard coatings have about double the resistance to grit blast abrasion of conventional anodized coatings of the same thickness.

The Sanford process is another method for applying hard anodic coatings to aluminum alloys. Coatings produced by this method are claimed to have a Rockwell hardness ranging from C50 to C58 and a Mohs scratch hardness of about 8.

The Hardaz process of producing hard anodic coatings is widely used abroad, particularly in England. This process is a unique combination of the processes used in the United States and uses a combination of a.c. and d.c. current. The process is generally used to build up extremely thick layers of hard coating for highly specialized applications.

Hard coatings for magnesium

—Along with chromium and nickel plating, anodizing has proved to be an effective method of increasing the hardness and abrasion resistance of magnesium surfaces. Two of the principal anodic treatments now in use are the HAE and Dow No. 17 processes. The HAE coating is formed in an alkaline bath and is light tan to brown in color. The Dow No. 17 coating is formed in an acid bath and is light tan to dark green in color. Both treatments are applicable to all magnesium alloys.

As shown in Table 6, the Taber abrasion resistance of these coatings can range from 25 to 800 cycles, depending on variations in treatment. Actually the hardnesses of the Dow No. 17 a.c. and d.c. coatings are equal. Differences in abrasion resistance are encountered, however, because of the difference in cohesiveness of the two coatings.

TABLE 6—ABRASION RESISTANCE OF ANODIZED MAGNESIUM SURFACES

Type of Coating	Thickness of Coating, in.	Taber Abrasion Resistance (CS-10 wheel, 1000-gm load), cycles
Dow No. 17 a.c.	0.0010	25
Dow No. 17 d.c.	0.0010	100
Dow No. 17 Plus Aluminum Oxide Dispersion	0.0025	800
Dow No. 17 Plus Organic Sealant	0.0010	200
HAE	0.0017	300
Chromium Plate	0.004	200

Aluminum Co. of America

***Aluminum gun blast tube** impeller and orthopedic brace are given hard anodized coating for added resistance to abrasion, erosion and corrosion.*

Metallizing Engineering Co., Inc.

Deep well pump rod *is sprayed with nickel-chromium-boron alloy for increased hardness and abrasion resistance.*

Sprayed Coatings

Metal coatings

Sprayed metal coatings provide an economical method of selective hardening. Since the metal spray is relatively cool as it impinges on the surface, coatings can be applied to all common metals and alloys, including aluminum, zinc, copper-base alloys, nickel, molybdenum, and mild, high carbon and stainless steels.

Composition of the sprayed metal is chemically and physically different from that of the original wire. In general, it is harder, more brittle and more porous than its equivalent in cast or wrought form. Because of the unique nature of the coating, hardness tests cannot be used to compare true hardness of sprayed metal with that of metal in other forms. They should be used only to compare one sprayed metal with another. In Table 7, for example, hardness of sprayed high carbon steel is given as Rockwell C36. Actually the hardness of the particles is approximately Rockwell C67, and the sprayed coating resists nonlubricated wear as well as hardened high carbon steel.

Sprayed metal coatings do not normally add to the strength of base metals although they do add some stiffening effect. Knowledge of the tensile properties of sprayed metal (see Table 5) is particularly important because they reflect the cohesion of the coating and thus its ability to resist the tearing away of entire particles by abrasive forces or by "welding" in more severe service.

Ceramic coatings

Ceramic coatings consisting of oxides can also be applied to metal surfaces by flame spraying. These coatings need no subsequent firing or baking, and will withstand temperatures up to about 4600 F, as well as erosion by gases at supersonic velocities. Oxides of aluminum and zirconium have received the most attention, although the process lends itself to application of many other types such as mullite and porcelain. Most of the ferrous and nonferrous metals have been successfully coated with alumina.

Typical properties of aluminum oxide, zirconium oxide and zirconium silicate, together with comparative properties of stainless steel, are listed in Table 8. The semimolten condition of the particles as they strike the surface permits them to deform and bond to the cool surface and to other deposited oxide particles. Roughening of the base prior to coating is usually required to improve the surface bond.

Coatings have a porosity of about 8 to 12% and are generally applied in thicknesses from 0.005 to 0.050 in. Heavier coatings are liable to possess residual stresses and to fail during sudden heating or cooling. Adherence of coatings is good in spite of the fact that the bond is primarily mechanical.

As-deposited coatings have a roughness of a few hundred microinches, although they can be finished to about 40 microinches rms by grinding with diamond or silicon carbide wheels.

Properties of the ceramic coatings indicate that one major area

of use will be in rocket, missile and jet engine components where high gas erosion and extremes of temperature are encountered. Commercial applications include pump shafts and impellers, mechanical seals, rolling mill rolls, and piping subject to cavitation. They can also be used as a hard coating for the softer metals such as aluminum, magnesium and mild steel.

Tungsten carbide

Extremely hard layers of tungsten carbide (92 tungsten carbide-8% cobalt) can be deposited on metal surfaces by the Flame-Plating process. Coatings range in thickness from 0.002 to 0.010 in. and have an over-all hardness of about 1350 Vickers (the carbide particles themselves exceed this hardness).

The coating particles are blasted onto the metal surface with a specially constructed gun. During

TABLE 7—HARDNESS AND TENSILE STRENGTH OF SPRAYED METALS

Metal	Rockwell Hardness	Ult Str, psi	Strain at Ult, % increase in length
Bronze	B78	29,000	0.46
18-8 Stainless	B78	30,000	0.27
High Chromium Stainless	C29	40,000	0.50
Iron	B80	28,000	0.25
Steel (0.10 C)	B89	30,000	0.30
Steel (0.25 C)	B90	34,700	0.46
Steel (0.80 C)	C36	27,500	0.42
Molybdenum	C38	7,500	0.30

Source: Metallizing Engineering Co., Inc.

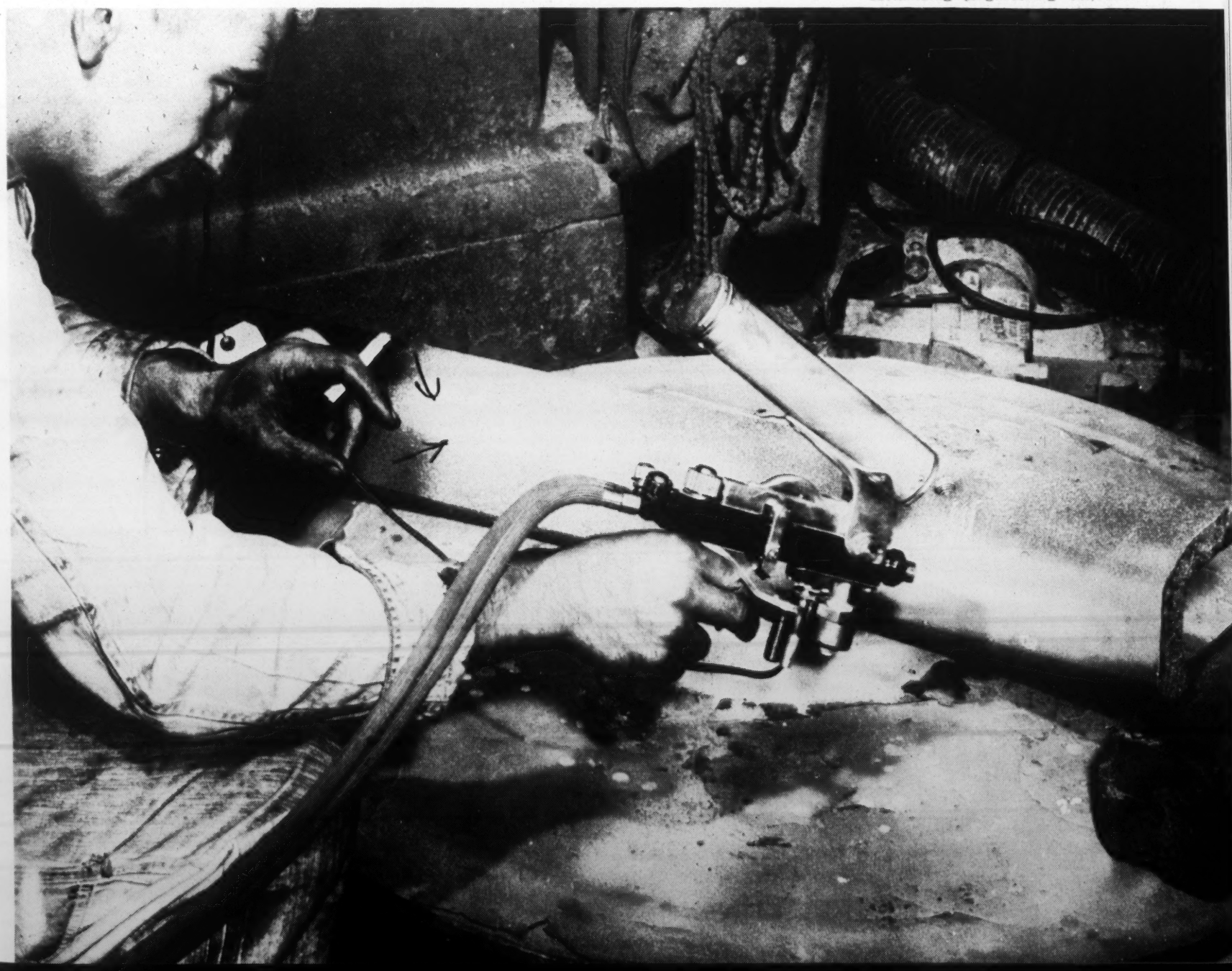
TABLE 8—CERAMIC COATINGS COMPARED WITH STAINLESS STEEL

	Aluminum Oxide	Stabilized Zirconium Oxide	Zirconium Silicate	Stainless Steel
Hardness, Knoop	2000	750	1000	400
Density, gm/cc	3.2	5	3.8	7.8
Melting Point, F	3600	4500	3000	2600
Coef of Ther Exp, (70-2550 F) per °F	4.3×10^{-6}	6.4×10^{-6}	2.3×10^{-6}	12.2×10^{-6}

Source: Norton Co.

Pulverizer throat ring *is sprayed with aluminum oxide ceramic to prevent abrasion by high velocity powdered coal.*

Metallizing Engineering Co., Inc.



application, the tungsten carbide particles become molten, and they fuse together on the metal surface. Although the temperature inside the gun barrel reaches 6000 F, temperature of the metal surface seldom exceeds 400 F.

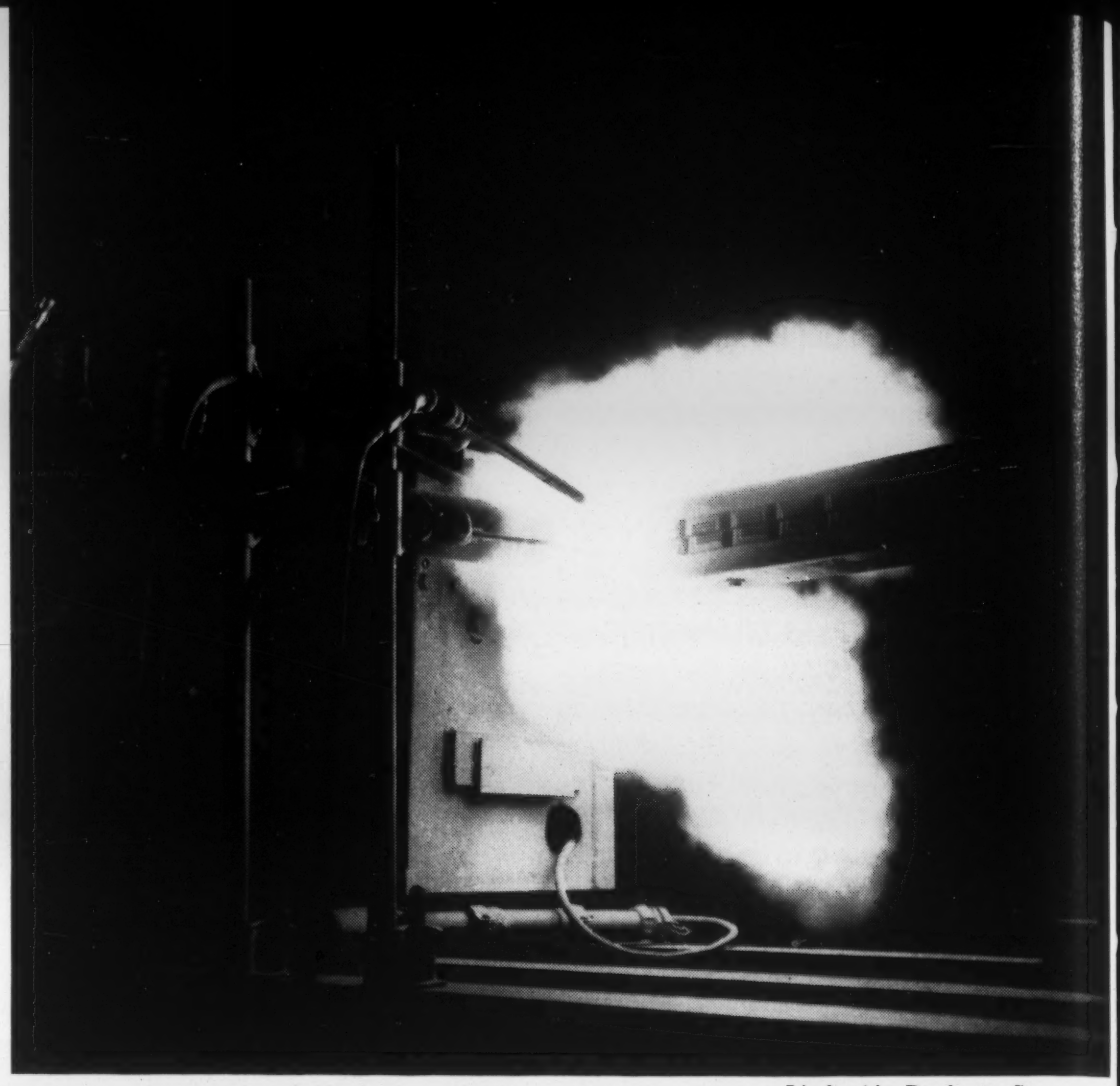
Practically all metals can be coated successfully, including steel, cast iron, aluminum, copper, brass, bronze, molybdenum, nickel, titanium and their alloys. Since base metal temperature seldom exceeds 400 F, changes in mechanical properties of metal parts are negligible.

Because the coating is formed by particles striking the surface, only those areas which permit free access are coated evenly. Narrow holes, blind cavities, deep grooves and sharp corners cannot be coated satisfactorily and should be avoided. Also, the process is not recommended for metal-cutting edges, since insufficient material is deposited to permit resharpening and service life is unsatisfactory.

A Flame-Plated surface looks and feels like fine emery paper. As-finished smoothness of the coating is about 125 microinches rms. Parts can be used in this condition or finished to various degrees of smoothness by standard carbide finishing methods. By diamond grinding and lapping, the coating can be finished to less than 1 microinch rms.

Principal applications for the tungsten carbide coatings to date include: aircraft engine parts, parts for high pressure hydraulic systems, knives for cutting various nonmetallic materials, textile and canning machine parts, forming tools and dies, and plug and ring gages.

In recent months the Flame-Plating process has also been used to apply aluminum oxide coatings. These coatings have a hardness of approximately 1000 to 1200 Vickers and a porosity of less than 1%. Thickness ranges from 0.001 to 0.040 in. Base materials that can be coated include all of the common engineering metals (except chromium and nickel plate).



Linde Air Products Co.

Gripper dogs *are coated with tungsten carbide by Flame-Plating process for increased wear resistance.*

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FILE FACTS

Chemical and Mechanical Requirements of Standard Investment Castings

(Alloys Standardized by Investment Casting Institute)

Carbon Steels (FE-1)

Grade	Code No.	Composition, %	Mechanical Properties			
			Condition	Min Tensile Strength, psi	Min Yield Strength (0.2% offset), psi	Min Elongation, % in 4D
Low carbon	01020	C 0.15–0.25, Mn 0.30–0.60 Si 0.20–1.00, P 0.04 max, S 0.04 max	Annealed	60,000	40,000	35.0
Medium carbon	01040	C 0.35–0.45, Mn 0.70–1.00, Si 0.20–1.00, P 0.04 max, S 0.04 max	Quenched and tempered	100,000	90,000	10.0

Low Alloy Steels (FE-2)

Grade	Code No.	Composition, %	Mechanical Properties			
			Condition	Tensile Strength, psi	Yield Strength (0.2% offset), psi	Min Elongation, % in 4D
Chromium molybdenum	04130	C 0.25–0.35, Mn 0.40–0.70, Si 0.20–0.80, P 0.04 max, S 0.04 max, Cr 0.80–1.10, Mo 0.15–0.25	Quenched and tempered	120,000 to 150,000	100,000 to 130,000	10.0
Chromium molybdenum	04140	C 0.35–0.45, Mn 0.70–1.05, Si 0.20–0.80, P 0.04 max, S 0.04 max, Cr 0.80–1.15, Mo 0.15–0.25	Quenched and tempered	130,000 to 160,000	110,000 to 140,000	8.0
Nickel chromium molybdenum	08730T	C 0.25–0.35, Mn 0.60–0.95, Si 0.20–0.80, P 0.04 max, S 0.04 max, Cr 0.35–0.65, Ni 0.35–0.75, Mo 0.15–0.30	Quenched and tempered	135,000 to 170,000	115,000 to 150,000	8.0

Corrosion and Heat Resistant Nickel-Base Alloys (NI-1)

Grade	Code No.	Composition, %	High Temperature Properties			Hardness	
			Test Temp, F	Min Tensile Strength,[b] psi	Min Elongation,[b] % in 1 in.	Condition	Rockwell C max
Chromium molybdenum tungsten	13200	C 0.15 max, Mn 1.00 max, Si 1.00 max, P 0.04 max, S 0.03 max, Cr 15.5–17.5, Mo 16.0–18.0, W 3.75–5.25, Fe 4.5–7.5, V 0.20–0.60, Ni bal	1500	50,000	10	As cast After 50 hr at 1475 F, air cooled	21 42
Chromium[a] cobalt molybdenum tungsten	13300	C 0.35–0.45, Mn 2.0–3.0, Si 1.00 max, P 0.04 max, S 0.03 max, Cr 23.5–26.5, Co 10.0–15.0, Mo 2.0–4.0, W 6.0–8.0, Fe 5.0 max, Ni bal	1500	48,000	6	As cast After 50 hr at 1475 F, air cooled	28 32

[a]Room temperature requirements: rate of strain 0.045-0.062 in./min; min tensile strength 65,000 psi; min elongation 1%.
[b]Time at temperature before loading: 30 min. Rate of strain: 0.045-0.062 in./min.

(Continued on p 145)

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Corrosion and Heat Resistant Cobalt-Base Alloys (CO-1)

Grade	Code No.	Composition, %	High Temperature Properties						Hardness	
			Test Temp, F	Min Tensile Strength,[a] psi	Min Elong,[a] % in 4D	Stress Rupture			Condition	Rockwell C max
						Load, psi	Min Life, hr	Min Elongation, % in 4D		
Chromium nickel molybdenum	13518	C 0.20–0.30, Mn 1.0 max, Si 1.0 max, P 0.04 max, S 0.04 max, Cr 25.0–29.0, Ni 1.75–3.75, Mo 5.0–6.0, Fe 3.0 max, Co bal	1500	52,000	10	20,000	15	8	As cast After 50 hr at 1475 F, air cooled	34 45
Chromium nickel tungsten	13530	C 0.45–0.55, Mn 1.0 max, Si 1.0 max, P 0.04 max, S 0.04 max, Cr 24.5–26.5, Ni 9.5–11.5, W 7.0–8.0, Fe 2.0 max, Co bal	1500	50,000	10	30,000	15	6	As cast After 50 hr at 1475 F, air cooled	34 42

[a]Time at temperature before loading: 30 min. Rate of strain: 0.45-0.62 in./min.

Silicon Brass (CU-1)

Grade	Code No.	Composition, %	Mechanical Properties		
			Min Tensile Strength, psi	Min Yield Strength (0.5% offset), psi	Min Elongation, % in 1 in.
Silicon brass	10525	Zn 10.0–16.0, Si 3.0–5.0, Pb 0.5 max, Fe 0.5 max, P 0.03 max, Al 0.1 max, Cu bal	60,000	26,000	16

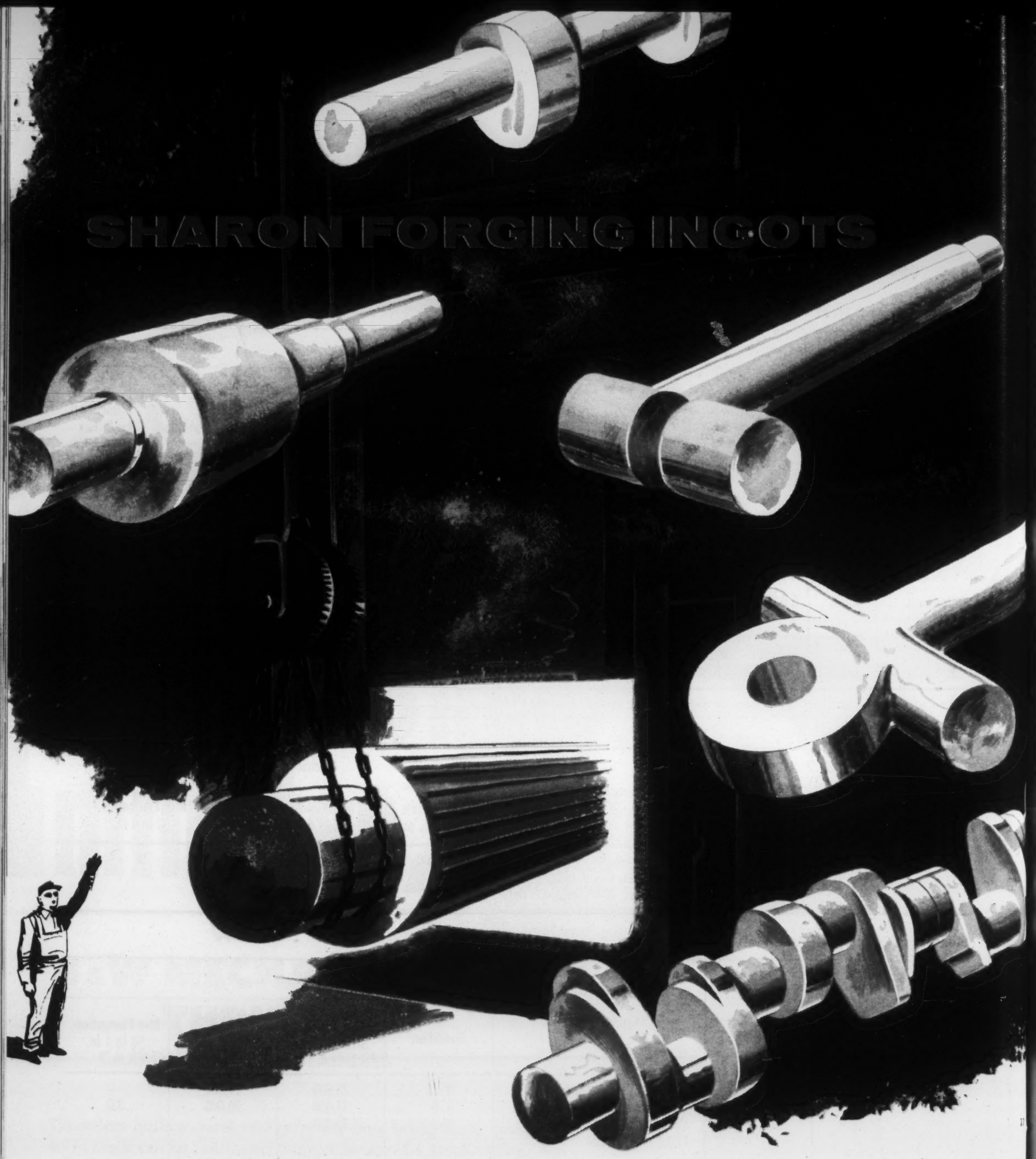
Heat Treatable Aluminum Alloys (AL-1)

Grade	Code No.	Composition, %	Mechanical Properties			
			Condition	Min Tensile Strength, psi	Min Yield Strength (0.2% offset), psi	Min Elongation, % in 1 in.
Silicon magnesium	20356	Si 6.5–7.5, Mg 0.2–0.4, Cu 0.2 max, Fe 0.6 max, Mn 0.3 max, Zn 0.3 max, Ti 0.2 max, Al bal	T-51 T-6 T-7	23,000 31,000 30,000	16,000 20,000 —	— 3.0 —
Silicon copper	20355	Cu 1.0–1.5, Si 4.5–5.5, Fe 0.6 max, Mn 0.3 max, Zn 0.2 max, Cr 0.20, Ti 0.20, Cr & Ti 0.08–0.30, Al bal	T-51 T-6	25,000 32,000	— 20,000	— 2.0

Magnesium Base Alloys (MG-1)

Grade	Code No.	Composition, %	Mechanical Properties		
			Condition	Min Tensile Strength, psi	Min Yield Strength (0.2% offset), psi
Aluminum zinc	21455	Al 8.3–9.7, Zn 1.6–2.4, Mn 0.10 min, Si 0.3 max, Cu 0.25 max, Ni 0.01 max, Mg bal	F T4 T5 T6	20,000 34,000 20,000 34,000	— — 11,000 18,000

Note: Code No. is from number system of "Cross Index of Chemically Equivalent Specifications and Identification Code" published by Secretary of Defense. All specifications set maximum limits for total of unspecified elements.



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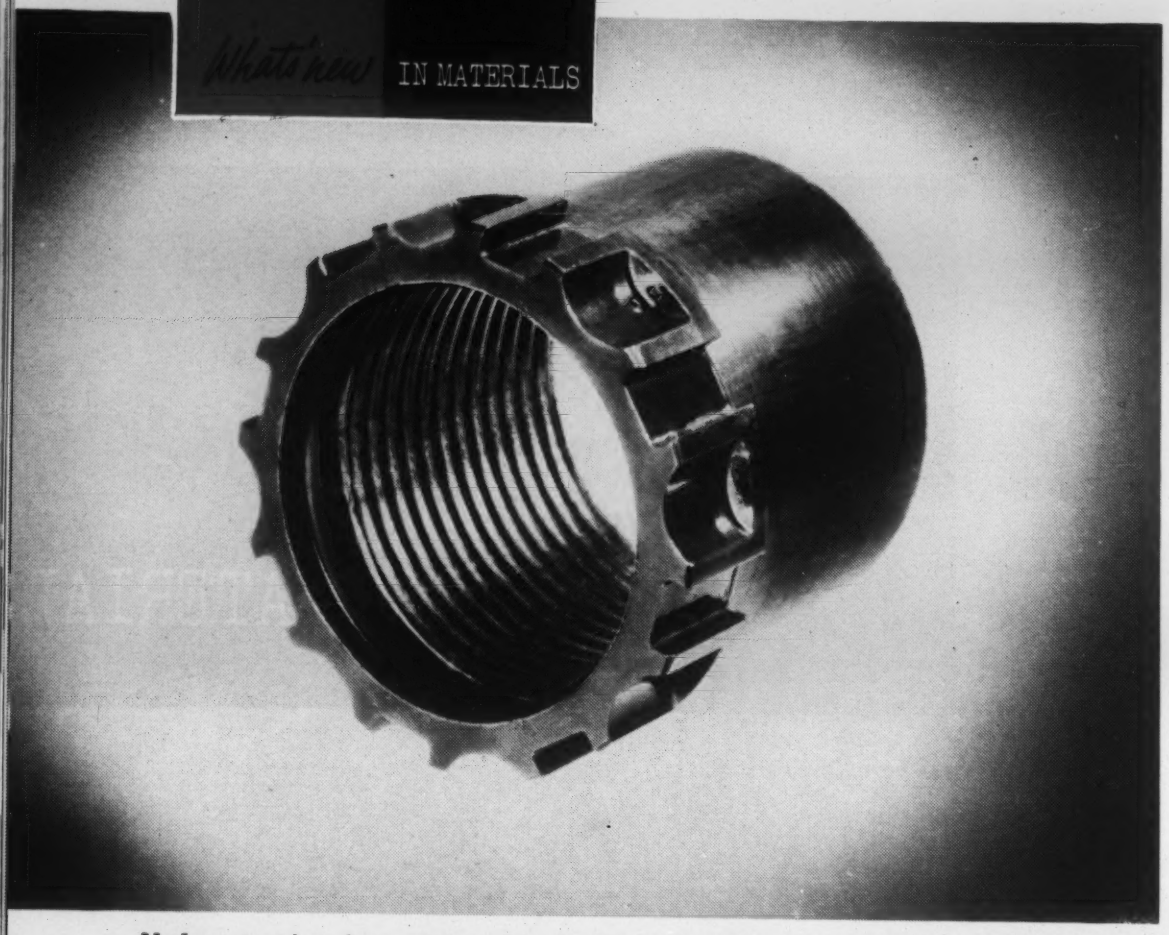
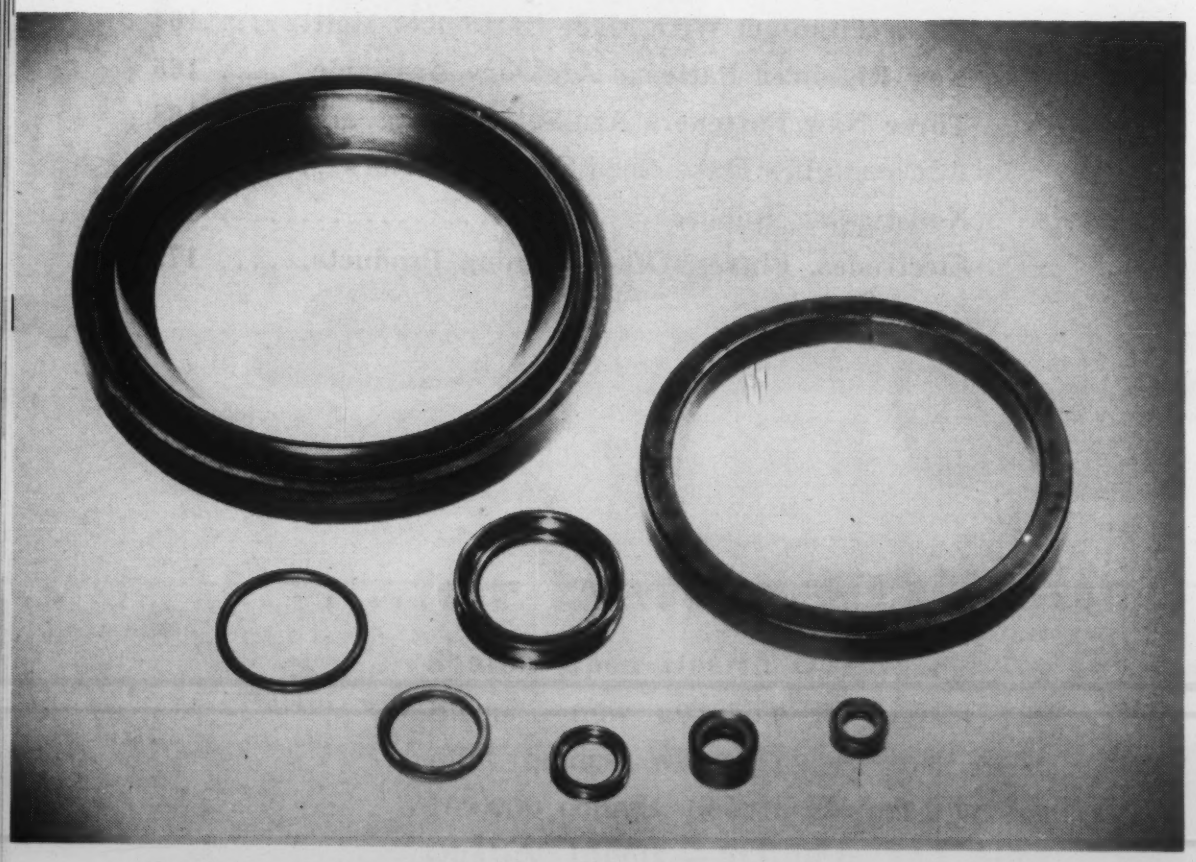


***Nylon** torsion bar suspension bushing for Fruehauf trailer contains molybdenum disulfide as a filler.*

Moly Disulfide Fillers Reduce Wear in Plastics

Rubber, brake materials benefit



***Rubber quad rings,** o-rings, ball seats and friction seals are filled with molybdenum disulfide to provide increased wear resistance.*

■ Molybdenum disulfide (MOS_2)—primarily used as a solid film lubricant — promises to provide unique benefits when used as an additive for solid materials. When added to plastics, it can provide lower surface friction, increased wear resistance, increased resistance to cold flow, and better dimensional stability and thermal conductivity. When added to rubber it can impart anti-seize characteristics and lower surface friction. It can provide stable frictional properties in asbestos brake linings and reduced fading in sintered brake and clutch facings.

According to a preliminary investigation by *Climax Molybdenum Co.*, advantages of molybdenum disulfide as an additive material are such that annual consumption of the material for this purpose is estimated at about 600,000 lb by 1962. The main drawback at present is the lack of reliable engineering data on materials filled with molybdenum disulfide. The bulk of data available apply to filled nylon and PTFE (polytetrafluoroethylene). (See M&M, Mar '56, p 100; Sept '56, p 103.) There are limited data on phenolic laminates filled with molybdenum disulfide, and little or none on PVC (polyvinyl chloride), polystyrene, epoxies and polyesters.

About 5000 lb of molybdenum disulfide were consumed by the rubber industry in 1955, but no definitive data are available on the properties of filled compounds. About 20,000 lb were used by friction material manufacturers in 1955; use of molybdenum disulfide as a filler has been explored more fully by this industry than by the plastics or rubber industries, according to the Climax report. However, available data are limited and spotty.

Plastics

The importance of molybdenum disulfide as a filler for plastics lies in the combination of lubrication characteristics and strength it provides. Of all plastics investigated, nylon shows the greatest promise. In standard nylon resins

molybdenum disulfide is added in quantities ranging from 5 to 20% to provide optimum properties. An accompanying table compares properties of a molybdenum disulfide–filled nylon with those of standard nylon and graphite-filled nylon.

Both molding and sintering grades can be produced. Sintered parts containing 10-20% molybdenum disulfide show no measurable wear after sliding against aluminum the equivalent of 6 miles under 80 psi load. Parts work smoothly at temperatures from 65 to 165 F. An accompanying table compares wear properties of sintered, filled nylon bearings with bearings made of extruded, unfilled nylon and of metal powder.

Successful applications of molybdenum disulfide–filled nylon parts to date include automotive chassis, suspension bushings, windshield wiper gears, speedometer gears, aircraft fuel pump rotors, conveyor wear strips, coil forms, and low impact cams, gears and bushings.

PTFE's extremely low friction coefficient cannot be improved by fillers. When molybdenum disulfide is added, however, the low coefficient is retained and the filler serves to reinforce the part, reducing cold flow and improving wear resistance. An accompanying table compares wear rates of molybdenum disulfide–filled PTFE bearings with those of bearings using other fillers.

Though there is little reliable engineering information on the effect of molybdenum disulfide on end properties of phenolic laminates, several applications have proved extremely successful. Adding 6-12% of the compound to the phenolic resin before impregnation imparts lower wear at higher temperatures and provides dry lubrication and high dielectric strength. Filled phenolic laminates are now being used in steel mill roll-neck bearings; high temperature bearings, where graphite breaks down as a lubricant; and slip rings on electrical insulation. In one application, a phenolic laminate roll-neck bearing containing about 10% molybdenum disulfide filler lasted 42% longer than a plain phenolic laminate bearing.

WEAR PROPERTIES OF SINTERED, FILLED NYLON BEARINGS
(Amount of Wear, in.)

Type Bearing	Inner Bearing	Outer Bearing	Spindle O.D.
Unfilled Extruded Nylon	0.0257	0.0332	0.0006
Sintered Nylon with:			
10% MoS_2	0.0000	0.0020	0.0001
100% Nylon	0.0010	0.0035	0.0005
15% Graphite	0.0005	0.0055	0.0002
30% Graphite	0.0013	0.0070	0.0005
20% Zirconium Silicate	0.0013	0.0018	0.0030
Metal Powder	0.0003	0.0024	0.0010

WEAR RATE OF FILLED TEFLON

Filler	Filler, % by wt	Filler, % by vol	Wear Rate, mg/hr[a]
None	0	0	0.74
Glass Fibers + Pigment	15-25	(–)	0.0015
Molybdenum Powder	85	58	0.0000
Graphite	15-25	(–)	0.0015
Copper	15-25	(–)	0.032
Mo S_2	15-25	(–)	0.038

[a]White, H. S., National Bureau of Standards Report No. 2882, Oct, 53. Bearings ½ in. long x ¼ in. i.d., run on Type 303 stainless steel shafts 0.25 in. in dia with clearance of 0.002 in. on dia; 2000 psi; room temperature; 150 rpm.

PROPERTIES OF FILLED NYLON EXTRUSIONS

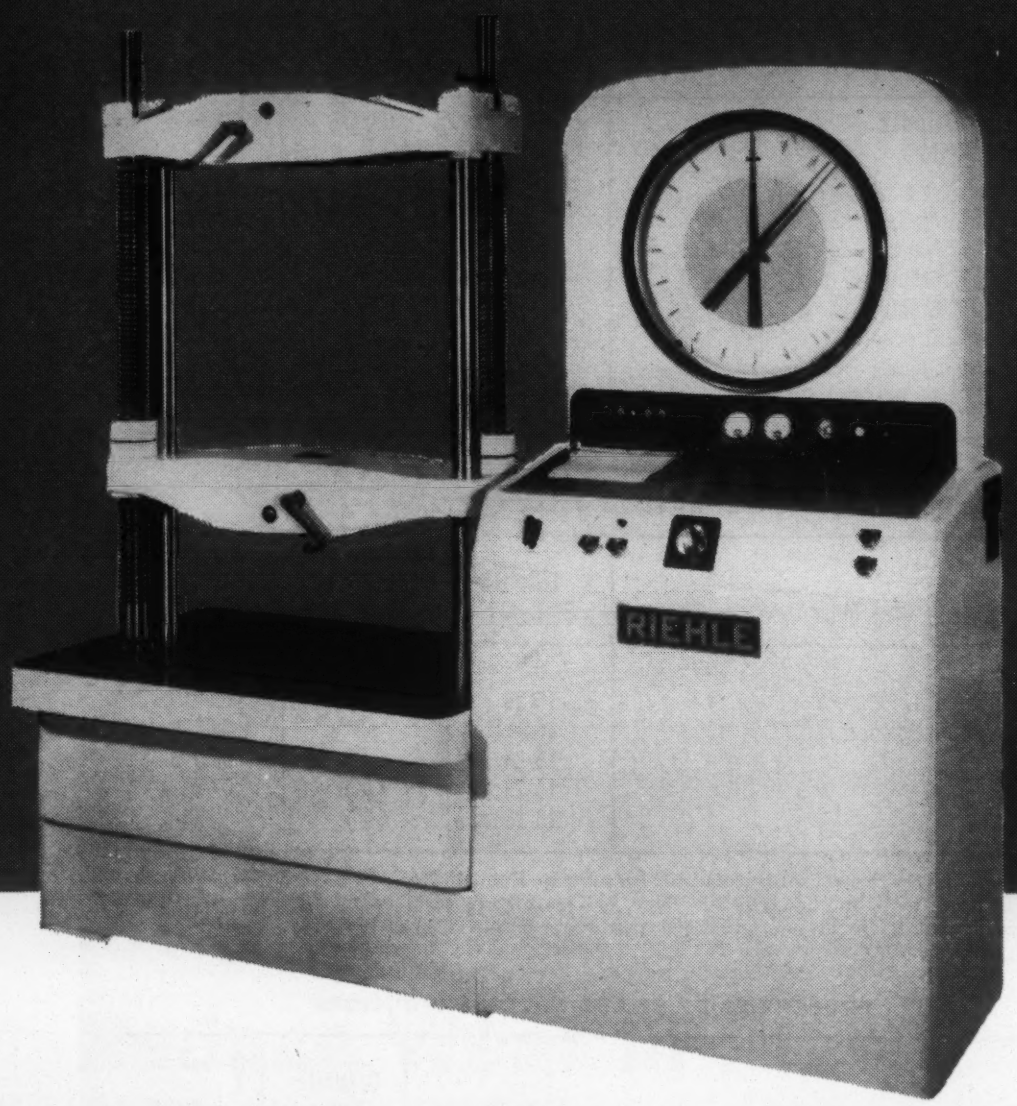
Property	MoS_2-Filled	Graphite-Filled	Unfilled
Tensile Strength (77 F), psi	12-15,000	12,000	11,000
Modulus of Elasticity (77 F), psi	598,750	527,750	400,000
Flexural Strength (77 F), psi	19,250	16,250	13,800
Hardness, Rockwell M	89	83	90
Izod Impact Strength (73 F), ft-lb/in.	0.62	0.62	0.94
Heat Distortion Temperature (264 psi), F	251	205	200
Coefficient of Linear Expansion, per °F	$2.3x10^{-5}$	$2.2x10^{-5}$	$5.5x10^{-5}$
Dielectric Strength (short time), v/mil	356	385	385
Specific Gravity	1.14	1.14	1.14

Source: Polymer Corp.

Of the other plastics surveyed, —PVC, polystyrene, epoxies and polyesters—PVC seems the most promising, though no startling results have been reported. Preliminary experiments were carried out by one company in the hopes that molybdenum disulfide could provide improved wear resistance for PVC phonograph records, in addition to providing shorter molding cycles by acting as an internal lubricant for the molding compound. Results to date have been negative.

With polystyrene, results indicate that molybdenum disulfide provides some improvement in the scratch resistance of surfaces, but only after quantities greater than 50% by weight are added. In such quantities the filler blemishes any

NOW... two more reasons for retiring inadequate testing machines



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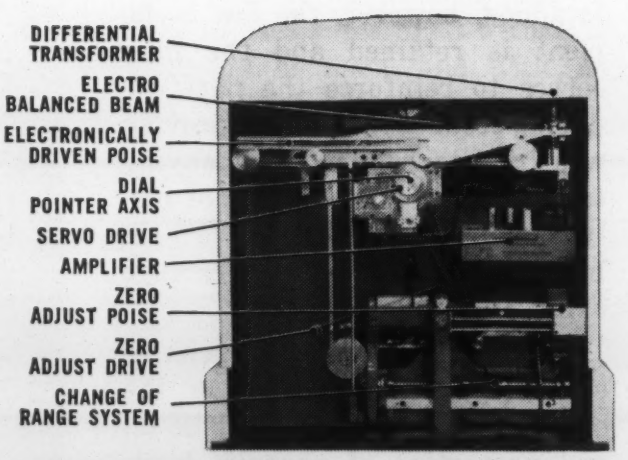
Here are the *sensitivity* and *rapid response* plus complete instrumentation you need for testing at elevated temperatures as well as at room temperatures.

With Riehle's new Electro-Balanced Indicating Unit, you know you are actually conforming with modern, more rigid testing requirements. No longer need you go on testing superficially with inadequate machines that just weren't intended for modern test procedures.

Riehle's new sensitivity and rapid response assure you of that flexibility and precision you must now have. The new Electro-Balanced Indicating Unit is available for both hydraulic and screw power testing machines — by Riehle.

For more information, Circle No. 530



SLIGHT MOTION AT BEAM END PROVIDES SUFFICIENT SIGNAL TO OPERATE THE SERVO MOTOR . . . AND MOVE THE POISE TO ESTABLISH FORCE EQUILIBRIUM.

NEW BULLETIN . . . MAIL COUPON

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clear or colored plastic.

No data at all are available on results with epoxies or polyesters. According to Climax, molybdenum disulfide additions might lower the high frictional characteristics of epoxies sufficiently to allow their use for high load, high impact bearing applications. Polyester recording tapes now being produced, are coated with silicones to reduce friction and abrasivity of the tape surface. Use of pure, micronized molybdenum disulfide to replace the relatively expensive silicones might be feasible.

Rubber

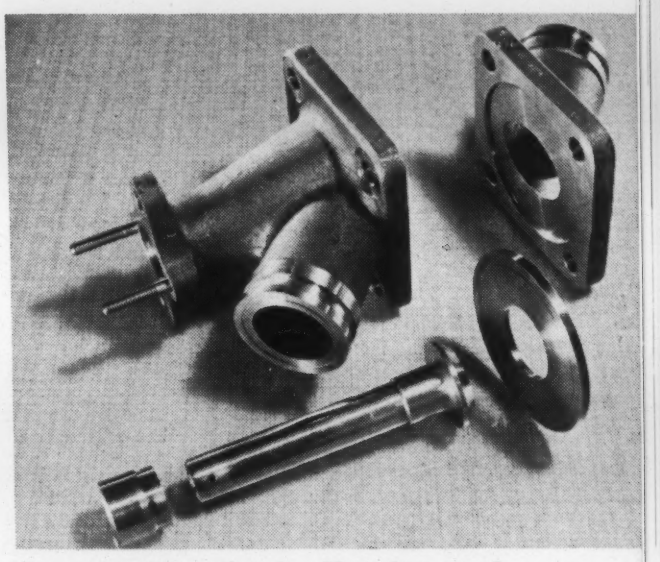
Though no actual test data are available, addition of molybdenum disulfide to natural or synthetic rubber in proportions up to 15% by weight lowers surface friction, increases wear resistance and improves anti-seize properties. Several rubber formulators have the filled stocks available, but only to meet definite customer specifications.

Present industrial applications for filled compounds include o-rings, ball seats, quad rings, packings for valves, and oil seals. One potential application is neoprene oil seals for military equipment. Present seals for rear-end axles must be so tight that they wear rapidly. A neoprene formulation filled with molybdenum disulfide might provide the needed lubricity and wear resistance.

Friction materials

The two principal uses for molybdenum disulfide as an additive to friction materials are in asbestos brake linings and sintered brake facings. In brake linings, the filler serves as a friction stabilizer, providing even, consistent surface friction. It reduces the squeal and squeak common to automotive brakes, and also reduces chattering.

In sintered brake facings, e.g., copper-tin-iron-graphite-silica, additions of molybdenum disulfide reduce "fade" characteristics. As a plane slows to a stop, for example, fading of the brakes develops a high retarding torque which sets up intense vibrations. Such brakes, when applied, reach temperatures close to 2000 F, but molybdenum disulfide does not seem to be affected by oxidation under these conditions.



Components *of 2-in. Y valve sand cast of Superston 40 for service in sulfuric acid.*

Aluminum Bronze Alloy Has Improved Strength

■ A high strength aluminum bronze alloy which is said to possess higher yield strength, greater toughness (Izod notched impact strength is 18-30 ft lb) and longer fatigue life than any known alloy of its kind will be produced for the first time in the United States by *American Brake Shoe Co.*, 97 Humboldt St., Rochester, N. Y. and *Ampco Metal, Inc.*, 1705 S. 36th St., Milwaukee, Wis.

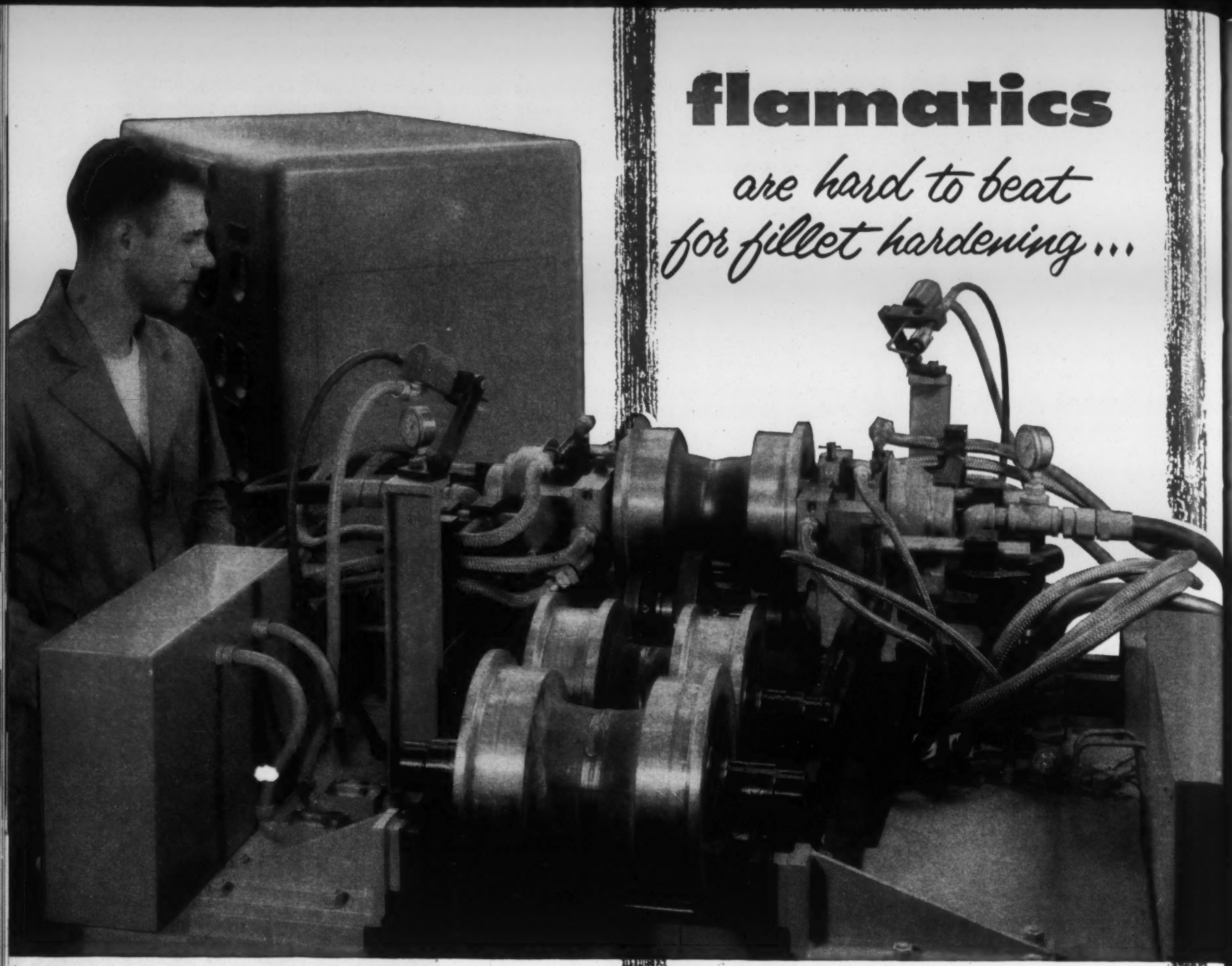
The new alloy, called Superston 40, is unique in that it contains about 12% manganese. Essentially a two phase alloy (alpha-beta), it has a nominal composition as follows: 75 copper, 8 aluminum, 2 nickel, 3 iron and 12% manganese. Whitish gold in color, the alloy melts at a low temperature

AVERAGE MECHANICAL PROPERTIES OF SUPUSTON 40

Form	Ten Str, psi	Yld Str, (0.5% elong) psi	Elong, % in 2 in.	Red of Area, %	Brinell Hardness (10-mm ball, 3000-kg load)
Sand Castings	98,000	48,000	26	28	185
Centrifugal Castings	105,000	50,000	30	30	190
Wrought Products (range)	100-135,000	50-85,000	35-15	40-15	180-230

Nuts and bolts *manufactured from Superston forged bar.*

Shell molded *Superston 40 has replaced stainless steel in these diaphragm valve seats.*



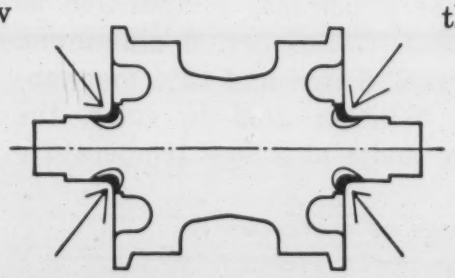
flamatics

are hard to beat for fillet hardening...

...and for many other selective surface hardening applications

Above you see a new, fully automated Cincinnati® Flamatic being used to increase strength and fatigue resistance of the axle fillet sections of 120 lb., SAE 1045 steel track rollers for crawler-type vehicles. Here's how it operates in the plant of a major manufacturer of heavy construction equipment:

Track rollers are delivered, one at a time, from the loading rack to the heating station. As the flame heads "scissor in," the part is rotated rapidly and an oxy-propane flame is applied to both axle fillet sections for 64 seconds . . . immediately followed by a 24-second spray quench. The part is then released to roll down the discharge trackway, while the next part is received in the fixture.



The operator is required only to initiate the cycle, which will continue automatically, as long as parts are on the receiving conveyor.

A case, ⅛" thick, hardened to Rc 55-53, is produced around the periphery of the fillet sections, with a wide transition zone behind it. (See part sketch.) Production is 38 parts per hour.

If you have a selective surface hardening problem, it will pay you to talk to Cincinnati. . .*builders of both Flamatic® (flame) and Inductron® (induction) hardening machines.* Discuss your requirements with a Process Machinery Division field engineer. He is ideally equipped to evaluate your needs and give you unbiased recommendations as to the most economical equipment for your work.

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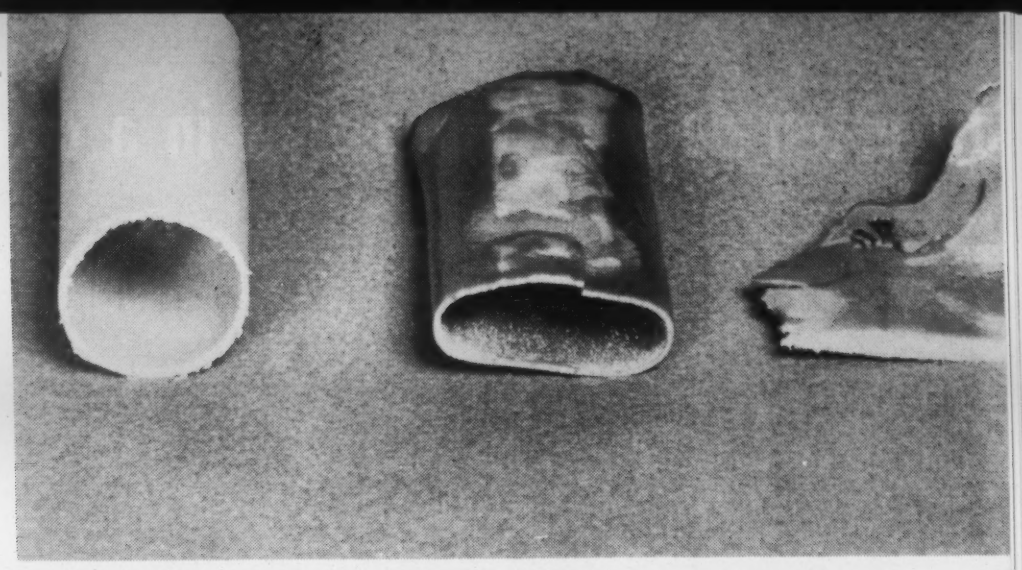


Comparison *of untreated polyethylene (right), irradiated polyethylene (center), and polyethylene modified by the new Sequoia process and then irradiated (left). These tubes were exposed to 300 F for 96 hr.*

(1814 F), casts better than ordinary aluminum bronzes, and can be easily forged, rolled or extruded. As shown in the accompanying table, Superston 40 offers excellent properties for sand castings, centrifugal castings and wrought products.

Originally developed by Stone & Co. in England for marine propeller use, the new alloy, because of its high mechanical properties and improved castability, is rapidly widening its field of application. It is particularly suited to production of difficult castings. Centrifugal castings 3 in. thick and up to 20 in. in dia and 12 ft long have been spun successfully. Presently, steel mill slippers cast with Superston 40 are undergoing trial in this country. Though not intricately designed, the slippers require high yield strength and good elongation. Other parts slated for comparative testing in steel mills include gears, connecting rods, slides, gibs and nuts.

Because of its exceptional hot working properties, the alloy can be used in the manufacture of wrought products ranging from strip as thin as 0.017 in. and fine wire to heavy plate and forgings. It has been rolled into condenser tube plates; it has been made into nuts and bolts; it can be extruded into rod, tube or more intricate configurations, and it can be made into welding rod for joining or overlay.

The improved castability of Superston 40 is attributable to less dross formation than conventional aluminum bronzes, resulting in cleaner castings with better surface quality; lower pouring temperature; and higher fluidity, which facilitates pouring of thin sections.

For more information, Circle No. 379

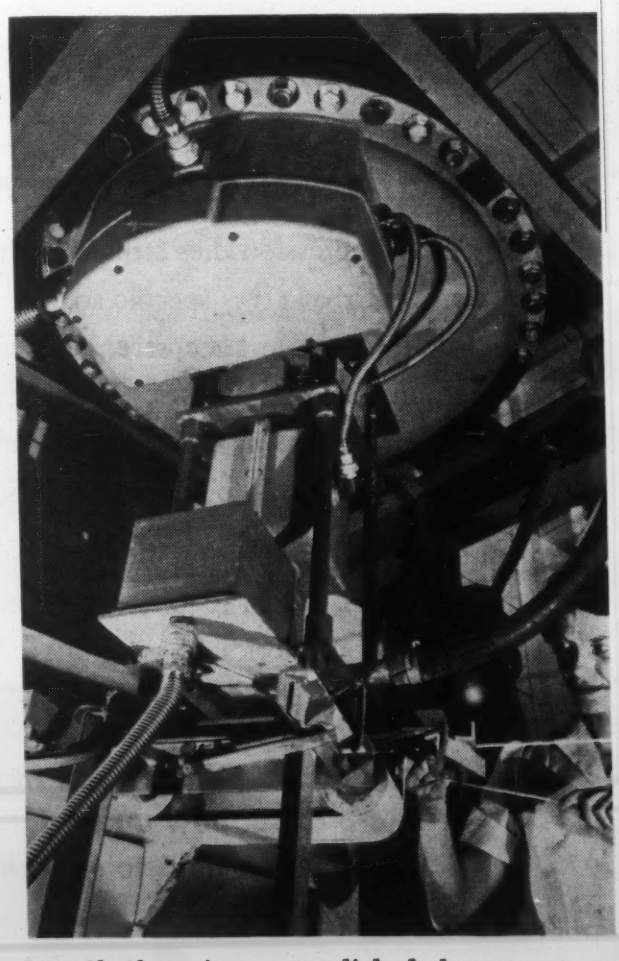
Irradiated Polyethylene Available as Wire Insulation

■ A new type of polyethylene with improved heat resistance and tensile strength, together with reduced cold flow and tendency toward stress cracking, results from irradiating modified polyethylene resins. The irradiating process is said to be adaptable both to linear (high density) and branch chain (low density or conventional) resins. Modifying the resin prior to irradiation is said to result in thermal and mechanical properties better than those of irradiated unmodified polyethylene.

The material, called Hyrad, is now available only as wire insulation, but the process seems adaptable to the production of other forms, such as film. According to the producers, wire insulated with Hyrad is unaffected when dipped in molten solder at 600 F.

Hyrad was developed jointly by *Sequoia Process Corp.*, Redwood City, Calif., and Stamford Research Institute. Exclusive licensing agreements have recently been reached between Sequoia and *Polymer Chemicals Div., W. R. Grace & Co.*, 3 Hanover Sq., New York, N. Y. Grace will supply modified high density polyethylene compounds and technical service to fabricators.

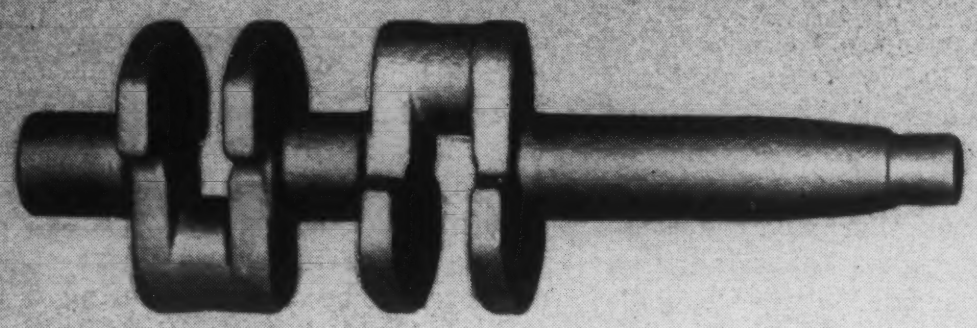
Two grades of the material are currently available from Sequoia. One grade, called Hyrad 90, combines the electrical properties of polyethylene with good form stability and absence of cold flow. Since it is an infusible material (crosslinked due to irradiation), the insulation does not melt at soldering temperatures, and shrinkage is said to be very small during prolonged soldering operations. It can be applied to tinned or



Irradiation *is accomplished by a General Electric electron beam generator.*

ow often do you find a flaw in a coin?

...or in a FORGING?

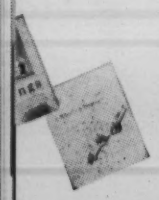


(Both are made by the same basic process)

When closed impression dies strike a coin, or hammer out a forging, they produce a result that gives specific advantages — **freedom from concealed flaws, closeness to tolerance, strength without bulk, superior resistance to impact and fatigue stresses.** These advantages mean fewer part rejects, greater overall economy, better product dependability and performance. These advantages are all found in forgings, the metal you can trust.

Do you have a part design problem? Are you now purchasing parts, made by other processes, which require extra metal to provide strength? Are you using weldments, or fabricated assemblies? You will find that often forgings can eliminate extras, and yet give you quality-plus advantages.

Make it a point to call in a forging engineer to learn more about how up-to-date methods and techniques of forging can help to reduce your products or part cost.



duce your cost by
ng forgings. Send
booklets, ☐ "What
a Forging?" and
"Management Guide
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Symbolic emblem of the Drop Forging Association

What's new IN MATERIALS

PROPERTIES OF HYRAD

	Hyrad 90	Hyrad 95
Tensile Str, psi[a]	1600	650
Elongation, %[a]	350	250
Dielec Con (81 F):		
1 mc	2.3	1.5
30 mc	2.3	1.5
Power Factor (81 F):		
1 mc	0.0005	<0.0005
30 mc	0.0005	<0.0005
Dielec Breakdown Voltage (15 mils), kv rms[a]	>12	—
Insul Resist, K factor[b]	>10,000	—
Solder Shrink, in.[c]	<1/64	—
Cold Bend	Withstands 3000-v rms dielectric test	

[a] When exposed 96 hr at 275 F and 96 hr at 300 F, proeprties remain same as at room temperature.
[b] When exposed 96 hr at 275 F, properties remain same as at room temperature..
[c] Test section immersed to ½ in. above bent portion of insulation (MIL-W-16878B).

bare copper conductors (gages 12 through 30) in any wall thickness. Standard wall thicknesses available are 10, 15, 30 and 45 mils.

Hyrad 95 is a cellular polyethylene that takes advantage of the low dielectric constant offered by entrapped gases. Walls of the cellular structure are said to retain most of the physical and electrical characteristics of Hyrad 90, but tensile strength and dieletric constant are modified by the cellular structure.

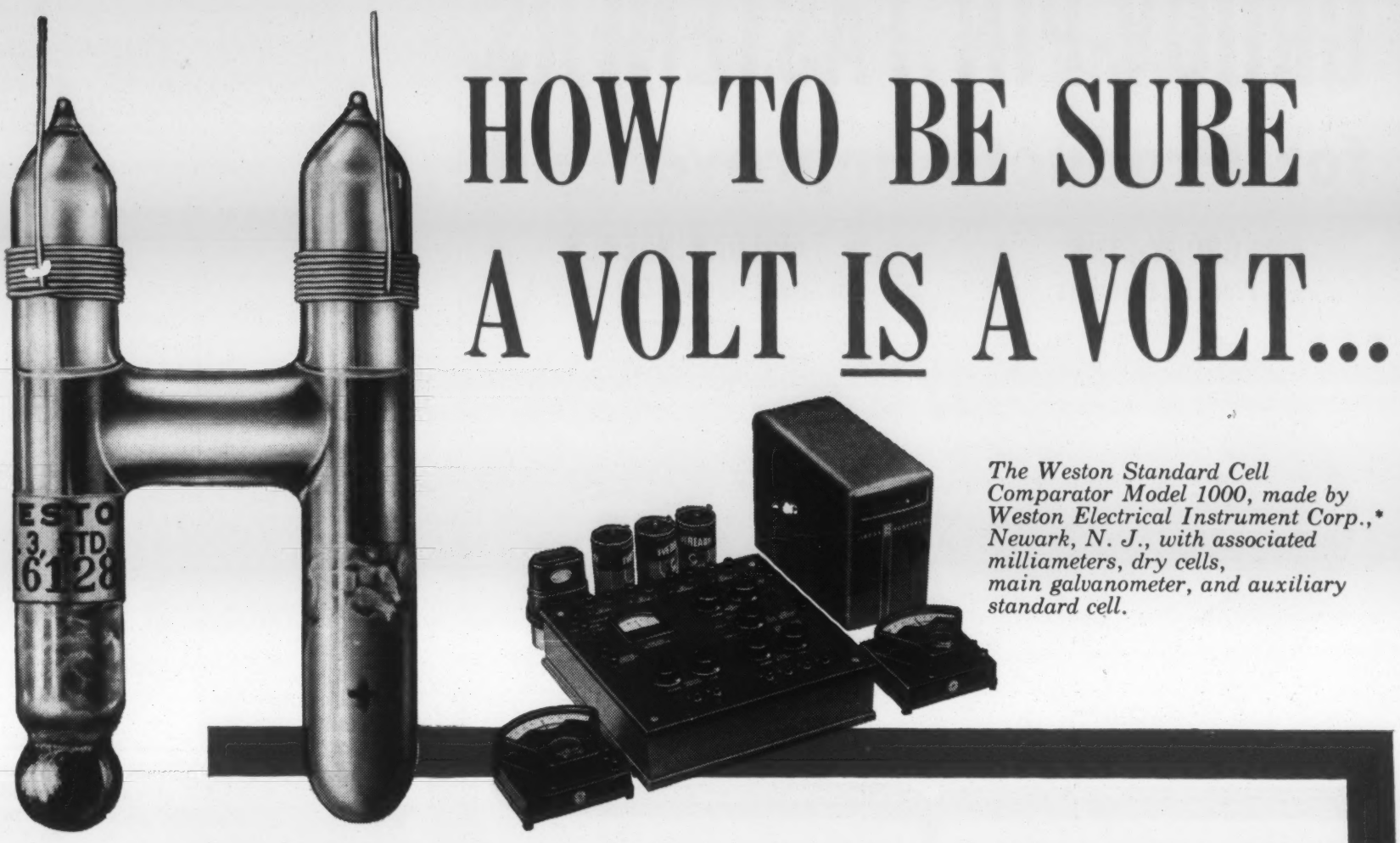
Resin Treated Wood Resists Acids, Alkalies

Wood impregnated with a phenol-formaldehyde resin, called KP Resin, is said to have potential use wherever dimensional stability, hardness and acid resistance are important. Developed by the *Wood Preserving Div., Koppers Co. Inc.*, Koppers Bldg., Pittsburgh 19, Pa., the resin treated wood is the result of a three-step operation that creates a chemical change within the wood cell structure and modifies the properties of the wood. (For information on

For more information, Circle No. 392

DRIVER-HARRIS ALLOYS AT WORK IN PRODUCT ADVANCEMENT

HOW TO BE SURE A VOLT IS A VOLT...



The Weston Standard Cell Comparator Model 1000, made by Weston Electrical Instrument Corp., Newark, N. J., with associated milliameters, dry cells, main galvanometer, and auxiliary standard cell.*

This H-shaped object, the saturated or "normal" form of the Weston Standard Cell, is the standard reference for electrical measurements. It is essentially a mercury cadmium wet cell hermetically sealed in glass. When kept at 20 degrees C., it maintains its voltage of 1.018636 volts for years. A bank of these cells at the Bureau of Standards in Washington, kept under oil at a constant temperature, is the basic electrical standard of the United States. This, however, is not the cell used by scientists and engineers in their daily work. Since the normal cell must be maintained at a constant temperature for accurate results, the unsaturated or "working" cell, which is portable and is not materially affected by temperature, is ordinarily used.

These working cells must be periodically checked against a bank of normal cells through the use of a comparator system. In the past only a few comparators existed outside the Bureau of Standards. However, the Weston Electrical Instrument Corporation has produced a simplified Standard Cell Comparator which provides the user of working cells, in conjunction with his own bank of temperature controlled normal cells, with an accurate means of standardizing these right in his own plant . . . at a great saving in time, cost and convenience.

THE WESTON COMPARATOR

The Weston Standard Cell Comparator is a specialized potentiometer wherein the voltage of a working cell under test is opposed to that of a normal cell to produce a voltage difference which, when added algebraically to the normal cell voltage, indicates directly the voltage of the cell under test. With a known normal cell voltage as a reference, the Comparator will measure to well within 5 microvolts the open circuit voltage of any cell in good condition.

With an instrument calibrated to such excellent accuracy as this one, it is worthy of note that Weston uses Driver-Harris Manganin wire for critical resistance networks in its system. Says Weston: "The success of the entire circuit, given accuracy of adjustment, depends upon the permanency of the Manganin, and upon its extremely low temperature coefficient of resistance and its low thermal emf to copper".

Your work may or may not need the extreme degree of accuracy that is a prerequisite here. Either way, Driver-Harris has an alloy that can reliably fill your needs. Manganin is only one of 112 special purpose alloys, produced by Driver-Harris. And each of these was originally custom-made . . . produced exactly to the specifications of someone who needed it. Put your specifications in our hands. You will gain the benefits of the 57 years of experience which has developed the largest variety of alloys ever made by any one company.

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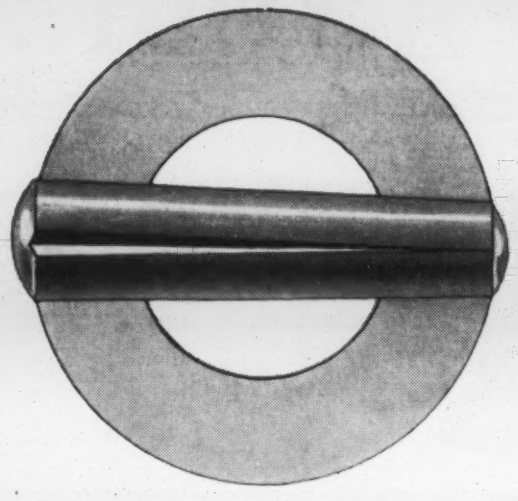
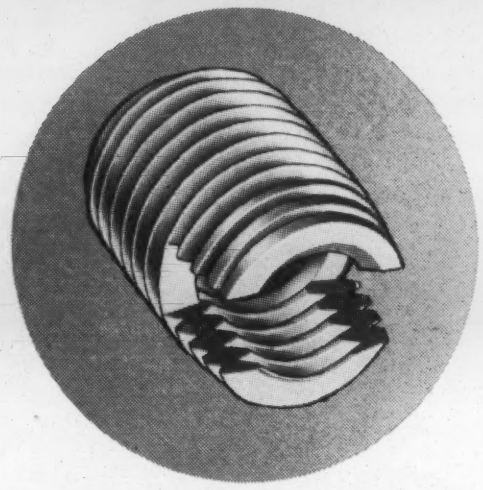


TAP-LOK® INSERTS
For Strong Threaded Connections



Defy Vibration — Shock

Reduce Assembly Time and Cost

No Reaming — No Tapping

GROOV-PINS The pioneer of all fasteners of this type, Groov-Pins are locking press fit fasteners which have proven their practical usefulness in a multitude of applications throughout more than 25 years. They hold well under conditions of shock and vibration, and eliminate the need for special hole preparation . . . reaming, peening, tapping, milling. Only a straight drilled hole is needed. Pins may be driven by hand, air cylinder or hydraulic press. They are usually cut from cold rolled steel (or other metals where conditions require) into which longitudinal grooves are rolled or pressed to deform the pin stock within controlled limits. When the pin is forced into a hole, the constraining action of the hole wall causes displaced material to flow back and effect a locking fit within its elastic range.

TAP-LOK INSERTS These internally and externally threaded bushings of steel or brass were designed as permanent fasteners to increase thread holding strength in comparatively weak materials . . . aluminum, magnesium, plastics, wood, etc. Their unique self-tapping feature substantially reduces assembly time and cost, by eliminating separate tapping operations, hole preparation, secondary staking. They withstand vibration without loosening and permit application of standard threaded fasteners without danger of stripping threads. The increased shear area obtained allows full utilization of the tensile strength of threaded fasteners. Used widely as original equipment, they are also excellent for salvage, and repair of stripped threads.

GROOV PIN TRADE MARK REG. U.S. PAT. OFF.

GROOV-PIN CORPORATION

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IN CANADA: Metal and Wood Fastening Devices Co., Valois, Montreal

For more information, turn to Reader Serivec Card, Circle No. 393

CHEMICAL RESISTANCE[a]

Chemical Solution	Hardness	
	Treated (KP)	Untreated
Water	170	100
Zinc Chloride, 20%	170	100
Sodium Chloride, Sat.	165	100
Phosphoric Acid, 10%	165	80
Chromic Acid, 25%	155	100
Sodium Bisulfite, 10%	155	90
Oxalic Acid, 10%	145	75
Sulfuric Acid, 10%	140	65
Acetic Acid, 10%	130	45
Nitric Acid, 10%	120	30
Sulfuric Acid, 10%	110	35
Hydrochloric Acid, 10%	90	40
Sodium Hydroxide, 15%	40	40

[a]A comparison of the hardness of KP resin-treated wood with that of untreated wood after both were aged 264 hr at 150 F in the solutions indicated.

other such materials, see M&M article on "Modified Woods," Mar '56, p 110.)

The resin treated wood remains easily workable and some of its machining characteristics are actually improved. The KP resin-impregnated wood also exhibits exceptional resistance to acids at temperatures that normally deteriorate untreated wood. The hardness and resistance to indentation of the treated wood is said to be doubled.

The treated wood is now being service tested in numerous installations, including filter press plates and frames. It is recommended for use in chemical process equipment for such applications as tanks and tank supports, covers for tanks, filter plates and frames, drainage members, fume ducts, flues and duck boards.

Nonwoven Fabric for Wrapping Coils

A nonwoven, felted polyester fabric called Scotch brand polyester web, is now available for wrapping coils, transformers, motors and other electrical components. It is made by *Minnesota*

still the winner

...and in high speed steels, nothing beats REX

The winner and still champion after fifty years is Crucible's REX high speed steel. *And now it's better than ever!* Recent improvements in manufacturing processes have given even higher quality and greater uniformity to every one of its properties.

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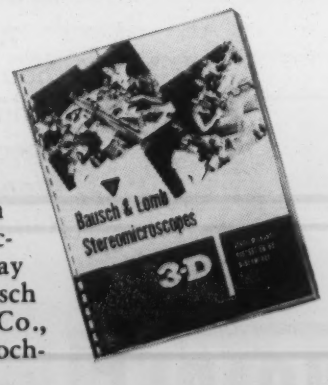

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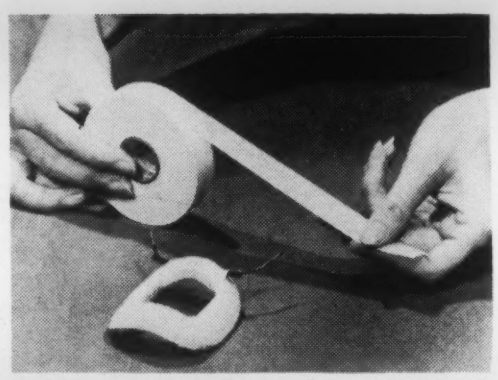
What's new IN MATERIALS



***Polyester fabric** conforms to irregular surfaces without pulling apart or slipping.*

Mining & Mfg. Co., 900 Fauquier St., St. Paul 6, Minn.

The nonwoven form of the material is said to allow rapid, complete and void-free impregnation, and to insure snug conformity of the material to irregular surfaces without pulling apart or slipping. The material is reported to have greater conformability than conventional cotton, glass or synthetic cloths. Another advantage of the fabric's felted, or web construction is its nonravelling edge, which provides resistance to edge tear.

Tests show that the new material has approximately 2½ times the varnish pickup ability of cotton cloth, and has a moisture absorption of 0.5% compared to a moisture absorption of 24 to 27% for cotton. According to the company, these properties permit substantial reductions in production costs through the elimination of extra dipping and baking cycles.

The white polyester web is available in calipers ranging from 6.5 to 9.5 mils in 36-yd lengths and standard widths up to 44 in.

Foam Polyethylene Available in Extrusions

An expanded foam polyethylene called Agilene-F, is now available in extruded forms such as sheet and rod from *American Agile Corp.*, P.O. Box 168, Bedford, Ohio. The expanded foam has a

Wherever metal needs heat

LINDBERG knows how best to apply it

If you have any part in choosing the equipment or methods of applying heat to metal it makes sense to talk it over with Lindberg. The safest way to be sure that you have the right answer for any application of heat to industry is to consult the most widely experienced experts you can find. We believe we have them here at Lindberg. Our business is concerned only with the development of industrial heating equipment and we manufacture the most complete line in the field; heat treating furnaces, melting furnaces, high-frequency induction units, ceramic kilns; big ones, small ones, electric or fuel-fired, built in our plant or field-erected.

Lindberg is a world-wide organization, and through its subsidiaries abroad has available the latest developments in heat applications in foreign industry. Over the years Lindberg research laboratories and its staff of furnace and process engineers have pioneered many of the most important developments in the industrial heating field, from the original Cyclone tempering furnace to the revolutionary new Induct-O-Ring shown and described below.

This design staff is ready to apply its experience to your requirements and recommend or create the equipment needed best to fulfill them, then thoroughly test the practicality of its recommendations through Lindberg's unique pilot plant operation. You can be sure you have the right answer when you leave it to Lindberg. So get in touch with your nearest Lindberg Field Representative (we have them in all major industrial centers) or write us direct.

Lindberg's Revolutionary New Induction Heat Treating Furnace

- For carbonitriding, bright hardening, carburizing of small parts
- No elements, no burners
- No fuel or electric connections in furnace
- Built like a fine machine tool
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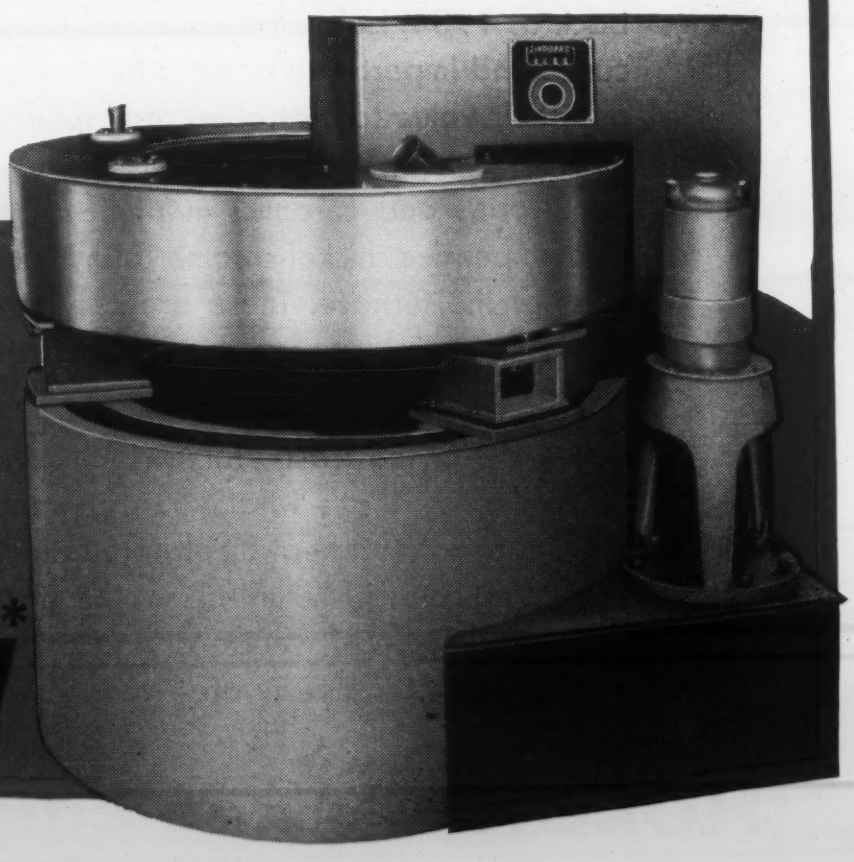
- Very low maintenance
- Quiet, automatic, trouble-free



LINDBERG

induct-O-ring*

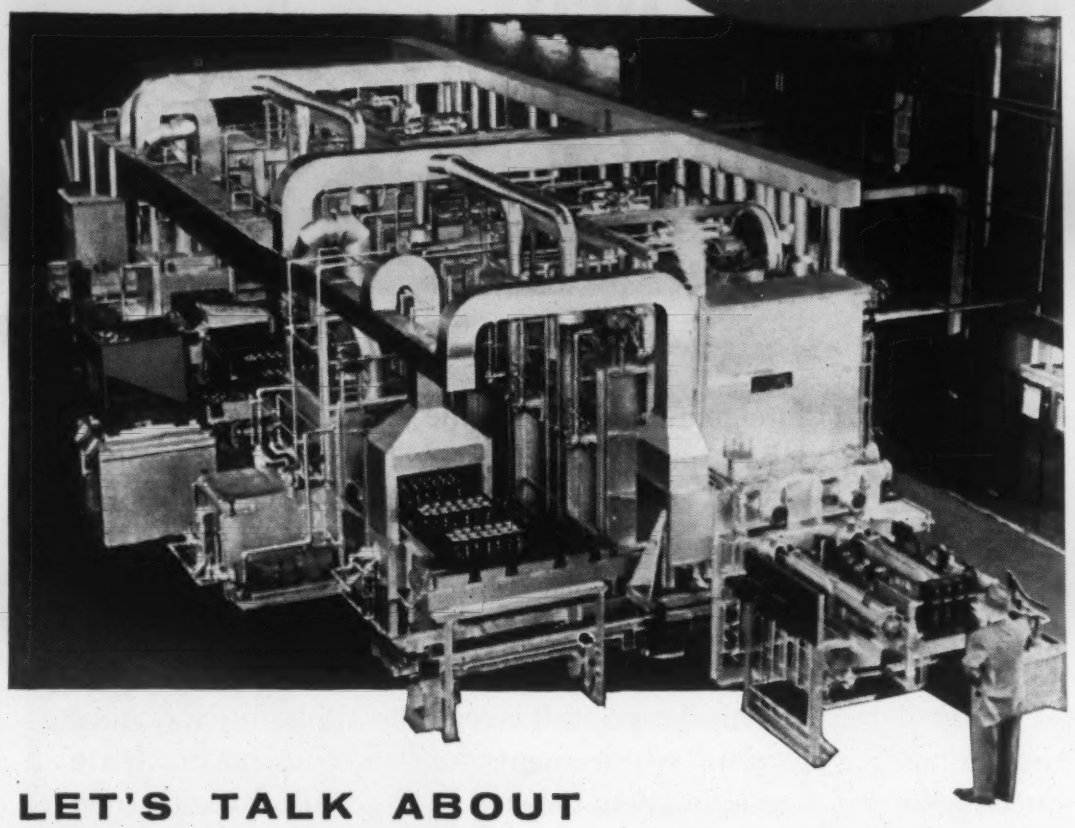
*U.S. and foreign patents pending

LINDBERG ENGINEERING COMPANY 2451 West Hubbard Street, Chicago 12, Illinois

Los Angeles Plant: 11937 S. Regentview Ave., at Downey, Calif.

For more information, turn to Reader Service Card, Circle No. 498

BLAZING THE HEAT TREAT TRAIL WITH HOLCROFT



LET'S TALK ABOUT

HEAT TREAT STANDARDS

When you take a long look at today's heat treat standards, you'll find that many of them were originated or perfected by Holcroft and Company.

For example, back in 1922 the removable electric heating element was developed. As far back as 1934, Holcroft recognized the significance and importance of equilibrium constants and their value to controlled atmosphere heat treating. And in 1945, was initiated the use of refractories and ceramics in place of scarce and expensive nickel-chrome alloys in vital parts of the furnace. These are only three of many, many innovations which have become heat treat standards in the industry.

Pioneering in the past—forward thinking for the future . . . that's what you get when you invest in a Holcroft heat treat installation. And that investment is returned in the form of higher quality control standards and lower heat treat costs. Better investigate—today!

HOLCROFT AND COMPANY

BUILT BY HOLCROFT & COMPANY DETROIT-MICH

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PRODUCTION HEAT TREAT FURNACES FOR EVERY PURPOSE

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CANADA: Walker Metal Products, Ltd., Windsor, Ontario

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uniform, small, closed-cell structure, the cells containing an inert, nontoxic and odorless gas. (For more information on polyethylene foams, see the M&M Foam Plastics Manual, June '56, p 143.)

Said to retain all the basic properties of polyethylene, the flexible foam material has good low temperature properties and is abrasion and moisture resistant. Its moisture resistance is slightly less than that of conventional nonexpanded polyethylene. It is also resistant to fungus growth, flaking and dusting. Possessing the same high chemical and solvent resistance as conventional polyethylene, the foam is resistant to all inorganic salts and most inorganic acids with the exception of very strong oxidizing acids. It is completely resistant to alkaline and caustic solutions and has no known organic solvent at room temperature.

The density of the material can be varied from 10 to 50 lb per cu ft by varying the amount of expanding material. As the density of the material is increased, the tensile strength is correspon-

***Unicellular,** expanded foam polyethylene appears suitable for gaskets, insulation, buoys and life floats.*

P&H Welding Positioners give you GREATER CAPACITY and GREATER VALUE for every dollar you invest

3000-LB. MODELS/LOAD-CAPACITY COMPARISON CHART

Capacity Shown Below at 12" off center of Rotation and Distances of Center of Gravity of Load from Table.

Distance Positioner	12"	18"	24"	30"	36"	42"	48"	54"	60"
P&H	**3000**	**2510**	**2160**	**1900**	**1690**	**1520**	**1390**	**1270**	**1180**
A	3000	2000	1500	1200	1000	–	–	–	–
B	3000	2250	1800	1500	–	–	–	–	–
C	2987	2187	1725	1424	1212	1056	935	839	760

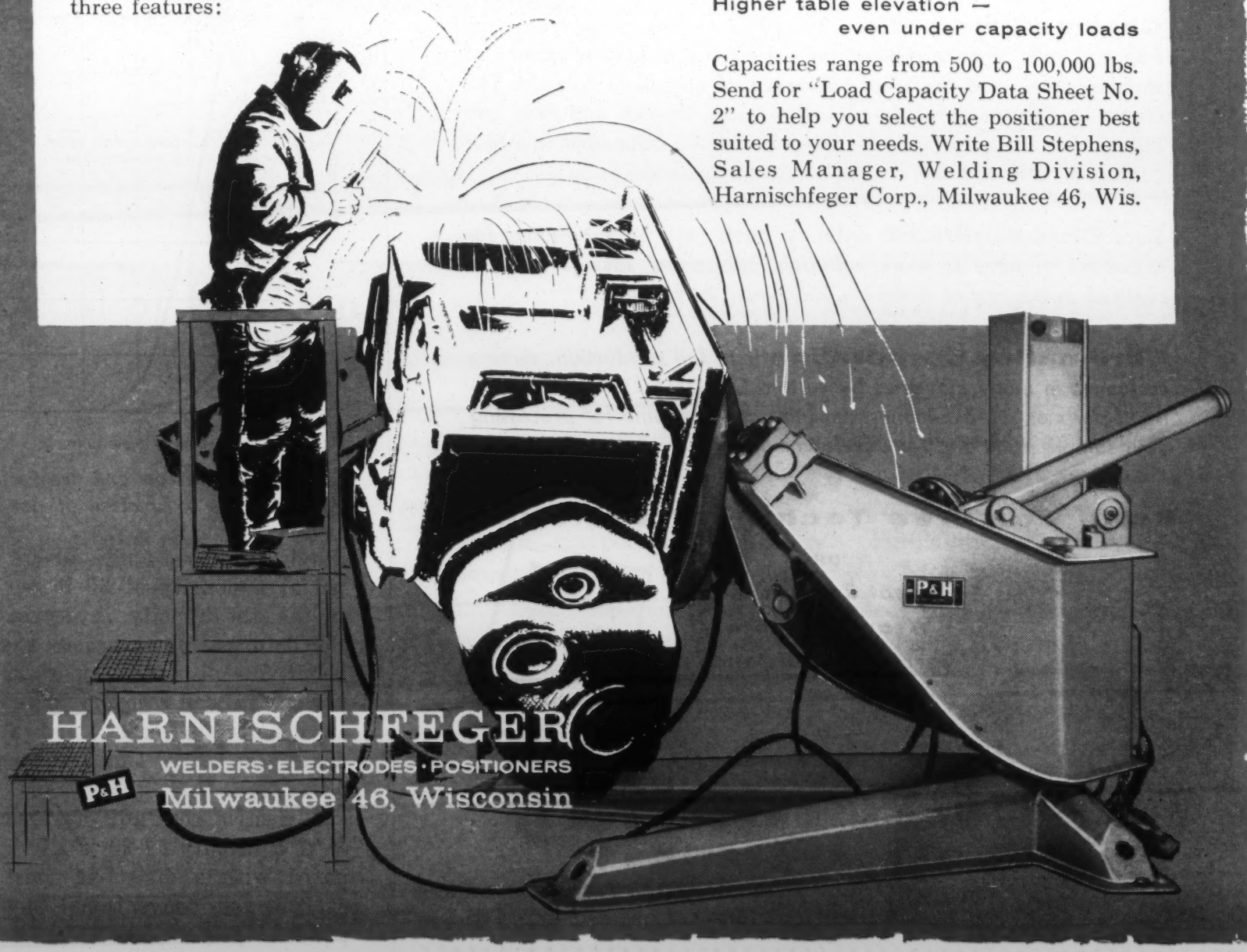
This chart shows how a typical 3000 lb. P&H welding positioner handles loads far beyond the positions where competitive makes quit! P&H positioners handle big, bulky or odd-shaped weldments with ease because of these three features:

More table tilt — 135 degrees

More clearance for rotation — no legs or posts interfere

Higher table elevation — even under capacity loads

Capacities range from 500 to 100,000 lbs. Send for "Load Capacity Data Sheet No. 2" to help you select the positioner best suited to your needs. Write Bill Stephens, Sales Manager, Welding Division, Harnischfeger Corp., Milwaukee 46, Wis.



HARNISCHFEGER

WELDERS · ELECTRODES · POSITIONERS

P&H Milwaukee 46, Wisconsin

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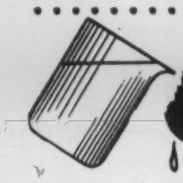
CHROMALLOY PROCESS COMBATS:

HEAT



CORROSION

WEAR

UNTREATED CHROMALLIZED

Low carbon steel, tested in gas flame to 1800°F for 24 hours. Expanded metal radiants used in gas range broilers. A leading appliance manufacturer has replaced stainless steel radiants with CHROMALLIZED mild steel at a saving of 26%.

Chromallizing *diffuses chromium into the surface of ordinary iron and steel parts to provide the corrosion and heat resistance of stainless steel, and the wear resistance of chromium carbide. The chromium diffuses uniformly into all recesses, threads and even into blind holes. The case formed is integral with the base steel so that it can't peel, chip or flake.*

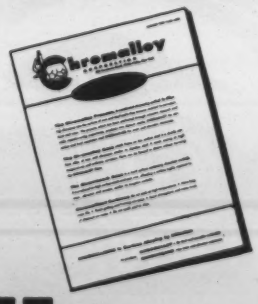
Since **Chromallized** *ordinary steels may be substituted for expensive or hard to work materials, substantial savings may be realized in the cost of materials, machining or forming.*

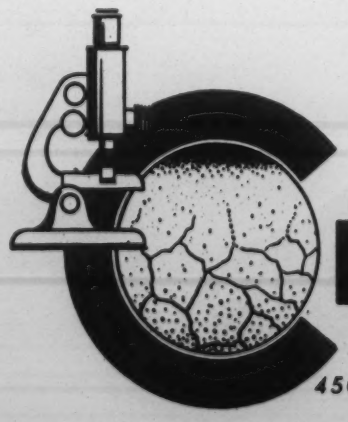
Chromalloy Corporation *is in full production, serving customers in many industries by custom CHROMALLIZING their finished parts or sub-assemblies. Facilities are available for processing your sample parts and for development work.*

Send For Free Technical Bulletins

on

Heat Resistance
Wear Resistance
Corrosion Resistance





Chromalloy
CORPORATION

450 TARRYTOWN ROAD • WHITE PLAINS, NEW YORK

Telephone: WHite Plains 6-0020

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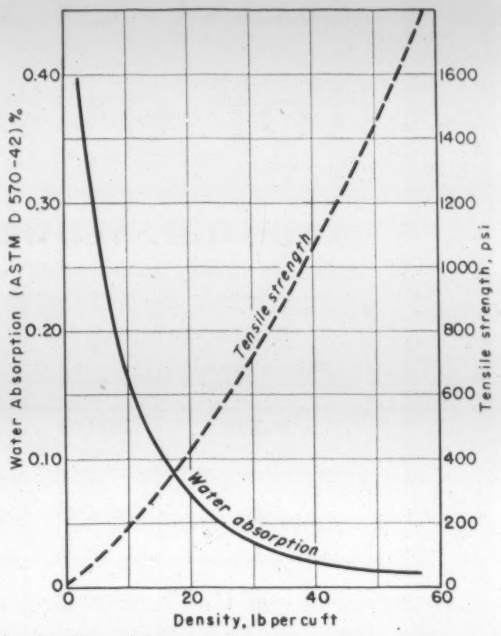
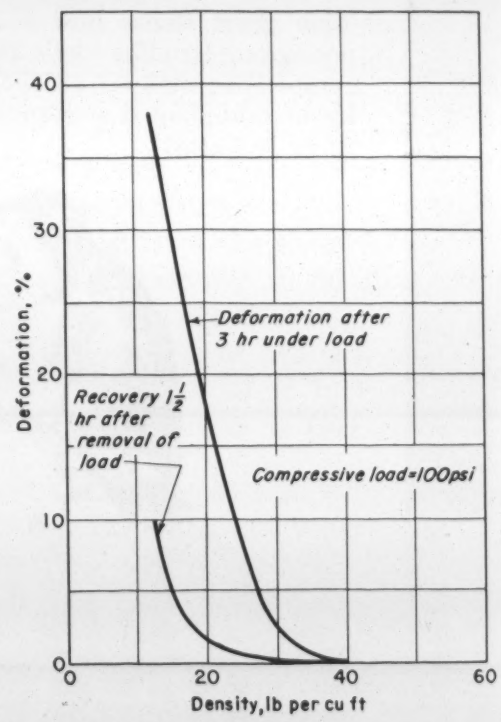


Tensile strength** and water absorption of Agilene-F, as a function of **density.



***Load deformation** and recovery of Agilene-F as a function of density.*

dingly increased and is about 700 psi at a density of 30 lb per cu ft. As the density is decreased, the deformation increases and is about 3% at a density of 29 lb per cu ft. Load rccovery increases as density increases, and at a density of 29 the load recovery is 93%.

Dielectric constant of Agilene-F at a density of 29 is 1.5, compared with a dielectric constant of 2.3 for conventional nonexpanded polyethylene. Dielectric

to re-create perfect tone . . . EXON 480

typical of the "Pin-Pointed Properties" in Exon vinyl resins

Exon engineers have combined properties so precisely in Exon 480 that they have created the specific resin for phonograph records.

A "biscuit" compounded of Exon 480 assures the finished recording of unusually high tonal quality, as well as breakage resistance.

For production economies, the higher bulking density of Exon 480 speeds banbury output as much as 25%. Other assets: excellent moldability, good heat and light stability, compatibility with vinyl plasticizers, stabilizers and pigments.

Pin-Pointing properties is the Exon way of matching your particular needs with the specific answer in a vinyl resin. The consistent success of fitting the resin to the job has made Firestone Exon industry's most complete source of vinyl resins.

Firestone

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RESINS

For details that will interest you in particular, call or write:

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INDUSTRY'S MOST COMPLETE LINE OF VINYLS ENGINEERED TO YOUR SPECIFIC NEEDS

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THIS IS FOR MEN...

. . . who are interested in the advantages of of PEARLITIC MALLEABLE CASTINGS

● You can slash production, machining and assembly costs with Albion Pearlitic Malleable Iron Castings. And, here's why:—

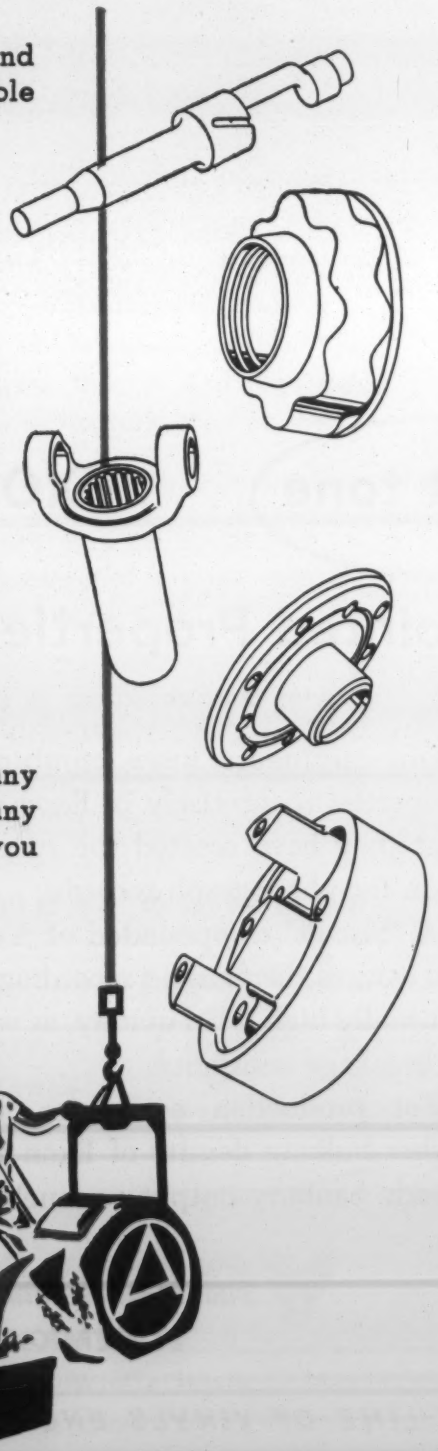
. . . Albion's pearlitic malleable irons offer complete freedom of design for greater savings in machining time, the elimination of excess metal and lower finished part cost.

. . . Albion's pearlitic malleable irons afford unusually fine wear resistance with excellent bearing properties. Maximum rigidity and prolonged fatigue life offers outstanding endurance. Yield strength comparable to steel forgings.

. . . Albion's pearlitic malleable irons have a fine, uniform grain structure that machines easily and accurately with exceptional mirror-smooth finishing qualities. Extremely adaptable to localized hardening for specific needs.

Contact the Albion Malleable Iron Company now . . . they'll be glad to show you how many ways Albion's pearlitic irons can save you time, tools and dollars.

Remember . . . Albion's Research and Development Laboratory facilities and competent engineering staff are ready to help you design better products that can be made at lower cost.



ALBION MALLEABLE IRON CO.

Albion, Michigan

For more information, turn to Reader Service Card, Circle No. 447

strength at this density (29) varies from 220 to 190 v per mil, depending upon the method of test.

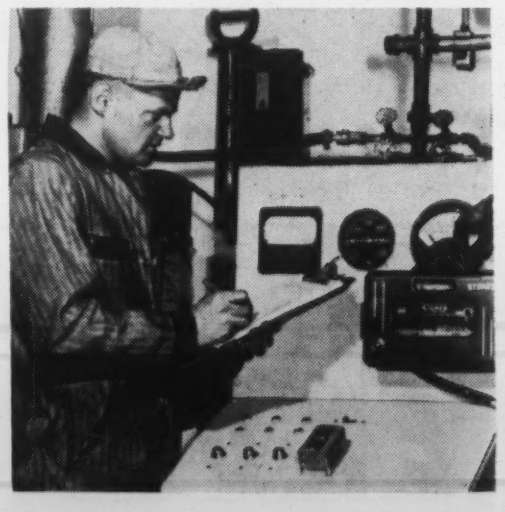
The expanded foam material, in addition to its availability in extruded forms, can be molded to meet customer specifications. It can be fabricated with common wood and metal working tools, and can be drilled, machined, sawed, hot gas welded, and friction and heat sealed.

The material is recommended for use as gasketing, cap and closure linings, low temperature and wrap-around insulations, sandwich cores, shock absorbers, packaging, buoys, void fillers, life floats and radiation shielding.

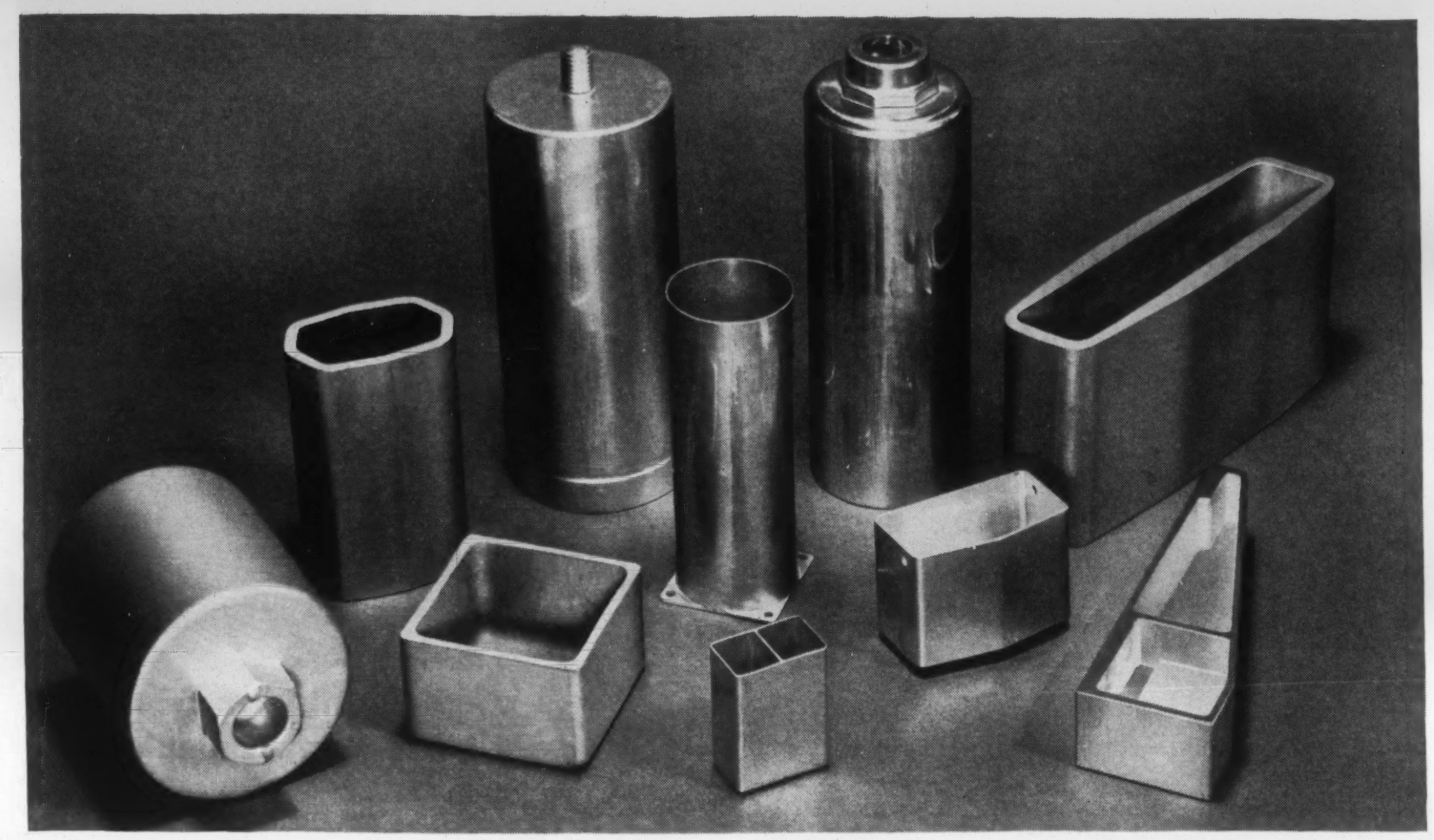
Clean Titanium Wire Made by Double Melt

Clean, ductile titanium wire, both alloyed and unalloyed, is now available in gages 0.025 to 0.030 in. from the newly organized *Johnston and Funk Titanium Corp.*, Wooster, Ohio. The titanium wire is recommended for titanium welding and other uses in the aircraft, chemical, paper and marine industries.

The wire is produced by a process developed by James H. Johnston and Edward R. Funk, founders of the company. It consists



Vacuum melt furnace *where titanium sponge is melted twice to produce a gas-free ingot for drawing titanium wire.*



SIMPLIFY DESIGN, GAIN SUPERIOR STRENGTH!

Specify Hunter Douglas Aluminum Impacts

Hunter Douglas Aluminum Impacts are solving a lot of important design problems in all types of industry. Here are quick answers to everyday questions.

HOW DO IMPACTS DIFFER FROM COLD FORGINGS? Basically, only in material used. "IMPACT EXTRUSIONS" are thin walled components extruded from 2S or *soft material.* "COLD FORGINGS" are thick walled shapes made from *heat treatable* aluminum alloys. For simplicity, we'll consider both synonymously.

HIGH STRENGTH—You will find all the properties of forged structures in impacts—exceedingly dense, fine grain, strength and toughness with unusual freedom from porosity and internal flaws...a natural for *high pressure applications,* either gas or liquid. In impact extrusions, flow lines actually follow part contours, adding extra strength. Often strength is satisfactory as extruded, without subsequent heat treatment. Our new alloy, HDX, gives tensiles as high as 85,000 psi with minimum yield strength of 80,000 psi for highly stressed applications.

GREATER SIMPLICITY—Complicated multiple piece assemblies can often be replaced with a single impact. An integral impact eliminates mechanical and/or welded joints and results in a smooth surface, unbroken by seams.

MORE DESIGN FLEXIBILITY—Generally, we can put extra metal where it's needed or thin up sections where required... like making bottoms of cans thicker than walls, adding integrally forged cavities or bosses of any shape, internal or external. Fluted or ribbed sidewalls, either decorative or functional, are easily produced by impact extrusions.

TOLERANCES—Hunter Douglas shines on accuracy...holds tolerances as close as ±.005" on specific diameters and matches screw machine tolerances on wall thicknesses.

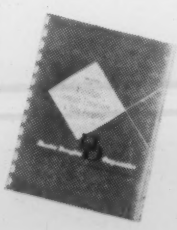
ZERO DRAFT—If you want straight, uniformly thick sidewalls, Hunter Douglas Impacts are for you. Zero draft cuts all unnecessary machining and reduces metal waste. Impacts usually require only trimming, drilling, tapping or minor clean-up.

SMOOTH, BRIGHT SURFACES—There's no scale or rust and surfaces range up to 125 microinches, as extruded...plenty smooth for lithographing or painting without secondary finishing. Real dazzlers result by polishing, satin finishing or anodizing. For extra wear or corrosion resistance anodizing is the answer.

UNLIMITED PART GEOMETRY—We've made impacts round, square, rectangular, triangular, octagonal and most other shapes. We do best if parts are symmetrical along the center axis, but good tooling often solves even a tough design problem. A sketch will enable us to advise or suggest means to an end.

WHERE TO USE IMPACTS—Here are rule-of-thumb considerations: hollow parts with one closed end; walls or surfaces of zero draft; lengths of 6 to 8 times O.D.; strength of hammered or pressed forgings; integral ribs, bosses or webs; tolerances of ±.005"; typical surface finishes of 125 microinches; concentric, multiple diameters.

WE'D LIKE TO HELP—
Our booklet gives valuable impact and cold forging information and our engineers are eager to advise. Simply write on your letterhead we'll do the rest.

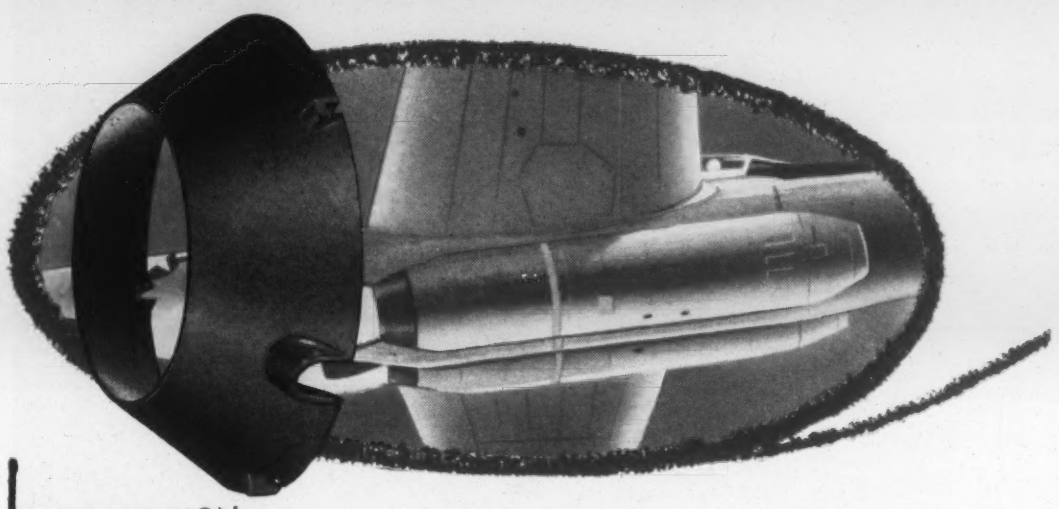


Hunter Douglas Aluminum Corporation

HUNTER DOUGLAS ALUMINUM CORPORATION • DEPT. MM-1, RIVERSIDE, CALIFORNIA • TELEPHONE OVerland 3-3030

THE SHAPE OF THINGS IN MOLDED SILICONE

SILI-CONE PROVES REAL COOL FOR JET AIRCRAFT EQUIPMENT



APPLICATION:
Thermal barrier for jet aircraft accessories.

PROBLEM:
The original part, along with drawings and molds, was presented to Acushnet by a well-known manufacturer of accessories for conventional and jet aircraft with orders to continue development with Dow-Corning 301 compound. The idea was to attain a part that would provide maximum physical properties at elevated temperatures of over 800°F.

SOLUTION:
Overcoming the high bulk factor of the compound was accomplished through the design and construction of a preform. Running the original mold in a special hydraulic ram equipped with controls permitting a wide range of temperatures and pressures, provided the necessary information in curing this compound. The resultant cure times and pressures enabled Acushnet engineers to design and construct a compression mold of hardened steel that made this part possible. Included in this project were small gaskets molded from Dow-Corning 301 that proved superior to metal in high heat insulating applications.

Pioneers in the advanced mold techniques and custom compounding of silicones, Acushnet now offers you immediate technical assistance in the molding and finishing of silicone resins.
Send for Acushnet "Silicone Rubber Brochure"

What's Your Shape?

Acushnet

ACUSHNET PROCESS COMPANY
NEW BEDFORD, MASSACHUSETTS

... *Precision Molded* **RUBBER, SILICONES - "APCOTITE" BONDING**
Address all communications to 750 Belleville Ave., New Bedford, Mass.

For more information, turn to Reader Service Card, Circle No. 508

of placing pressed titanium sponge in a water cooled copper crucible, where the metal is vacuum melted twice. After the second melt, the wire is drawn from the titanium ingot. This double melting procedure is used in order to eliminate such gases as hydrogen, nitrogen and oxygen,whose presence in titanium, even in minute quantities, causes embrittlement.

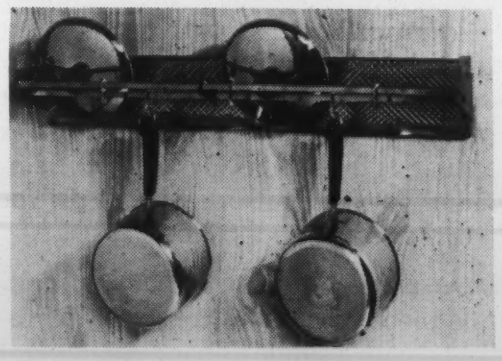
New Rigidized Patterns Are Now Available

Rigidized Metals Corp., 600 Ohio St., Buffalo, N. Y. has announced the development of a new process called Custom-Rold that permits unusual effects with Rigidigtex metal patterns. The company's line of standard patterns can be rolled into prescribed areas of the sheet, leaving the remaining portions of the sheet plain.

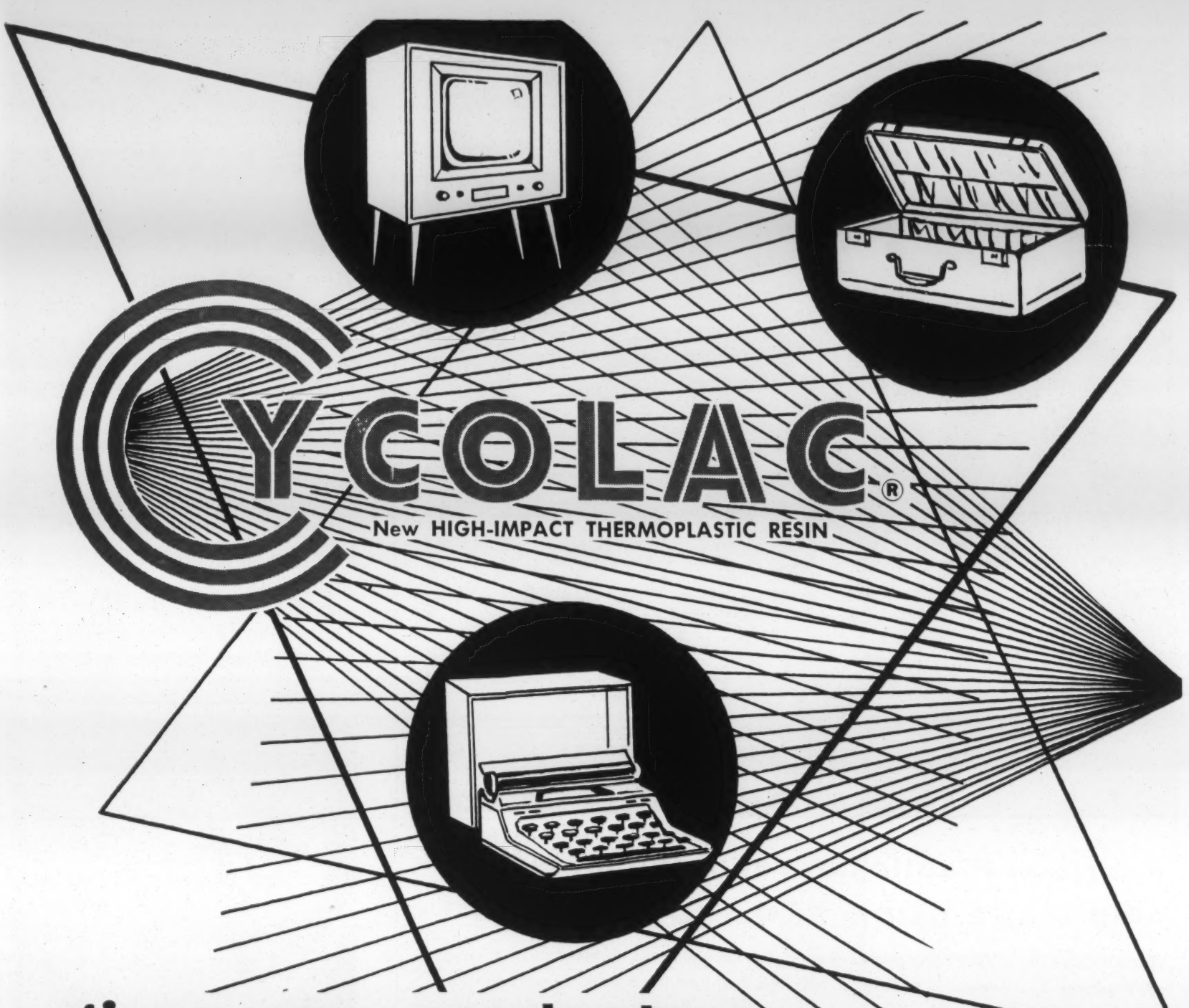
Thus, various arrangements of patterned and plain areas are available. One possibility is stripe patterns, obtained by rolling patterns in bands. Another is plain or rigidized areas arranged in a geometric pattern, perhaps shaped to simulate a trademark. The patterns are available in stainless steel, aluminum and other ferrous and nonferrous metals.

The patterns can be used as trim material for ranges, refrigerators, washing machines and other household items.

(more What's New on p 168)



***Pot and cover rack** shows a Custom-Rold design with plain metal areas at top and bottom folded over to meet design requirements.*



gives your products a NEW DIMENSION for selling

THE PERFECT RESIN FOR THE MANUFACTURE OF ANY PRODUCT THAT DEMANDS . . .

- Chemical Resistance
- Lightweight
- Non-Corrosion
- Dimensional Stability
- High Impact Strength
- Machineability
- Economic Molds
- Low Brittle Point
- High Heat-Distortion

Check In To The Tremendous Manufacturing Possibilities Offered Thru the Use of CYCOLAC

If you are in the business of manufacturing post-formed business-machine housings, typewriter cases, containers, signs, instrument cases, luggage, etc. CYCOLAC sheet can be produced by extrusion, calendering or press-polishing. CYCOLAC sheet is tough yet lightweight; low shrinkage, is colorful, and can be embossed or grained, solvent-welded, sawed, drilled, buffed, painted, etc.

Get the facts . . .

WRITE TODAY FOR TECHNICAL LITERATURE

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MARBON CHEMICAL . . . *Precision Resins for Precision Made Products*

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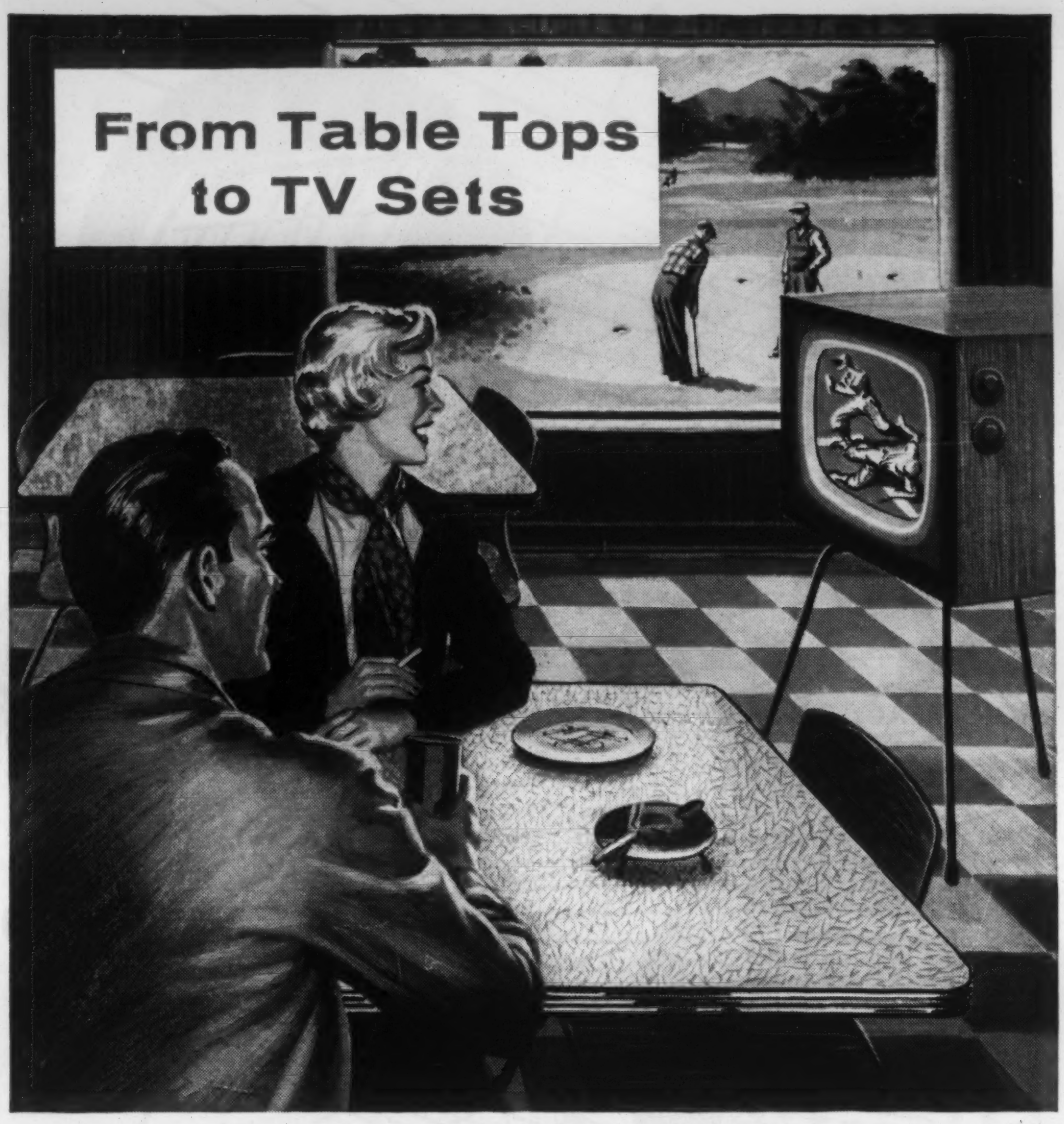
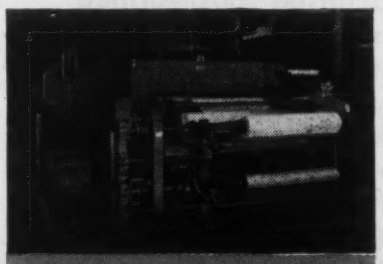


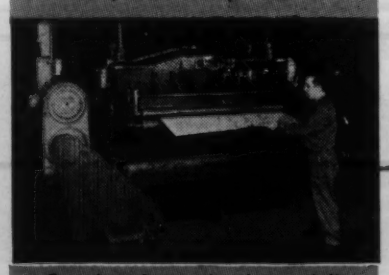
Fabricon Plastic Impregnated Materials help MAKE GOOD PRODUCTS BETTER!

When it comes to plastic impregnated papers for laminating or molding applications, you'll do well . . . *always* . . . to think of Fabricon *first!* First for melamine impregnated patterns, wood grains, solid colors, and translucent overlays for durable decorative laminates. And first, too, for phenolic impregnated N.E.M.A. industrial grades for countless electrical, mechanical and structural uses.

Yes, regardless of what your requirements are for plastic impregnated papers, you'll find that Fabricon has what it takes to deliver the quality and service you're looking for. Years of experience with all types of thermosetting resins and fillers. Complete laboratory facilities for developing new products and processes. Special production equipment designed for continuous, precisely controlled operation. Plus facilities, too, for slitting, sheeting, and die-cutting to size and shape required.



Giant impregnating ovens having roll capacities up to 90" in width assure efficient, economical production.



Complete slitting, sheeting, and die-cutting facilities help reduce costs.

But papers for industrial and decorative laminates are only one of the many different types of plastic impregnated materials now being produced by Fabricon to help make good products better. Others include asbestos, glass cloth, cotton duck, filter cloths and papers, plus a number of other special materials developed exclusively by Fabricon to fulfill the specific requirements of a wide range of products, *perhaps yours included!*

Want more detailed information on Fabricon products, facilities, and services? Write for it today!

FP **FABRICON PRODUCTS**
A Division of The EAGLE-PICHER Company
1721 W. PLEASANT STREET
RIVER ROUGE 18, MICHIGAN

Reinforced Plastic Moldings • Plastic Impregnated and Coated Materials

For more information, turn to Reader Service Card, Circle No. 545

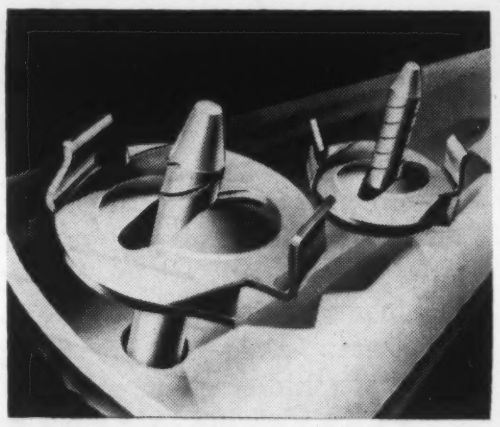
What's new IN MATERIALS

Three New Fasteners Are Self-Locking

Three new self-locking fasteners have been developed. They are designed respectively for thread cutting, high strength and stainless steel applications.

1. For thread cutting

Designed to hold die cut or cold forged nameplates, emblems and trim against sheet metal surfaces, a self-locking, thread cutting fastener called TCF, has been announced by *Carr Fastener Div., United-Carr Fastener Corp.*, Cambridge, Mass. Spring take-up is claimed to guarantee flush mounting on flat or contoured surfaces.



Spring take-up *feature of fastener is specially designed to hold nameplates and trim against surfaces.*

The fastener makes a water tight seal when used with a preassembled plastic sealer. (The sealer precedes the fastener onto the stud so that it is not damaged by the thread cutting fastener.)

Said to cut deep clean threads on studs, even those that are chromium plated, the low cost, reusable fastener is available to fit 1/8 and 3/16 in. studs.

2. For high strength

A blind application fastener, made of heat treated alloy steel and said to offer unusual pull-together qualities, has been announced by *Huck Mfg. Co.*, Detroit, Mich. Called the Tau Bolt, the fastener is of pin and sleeve design with a positive mechanical

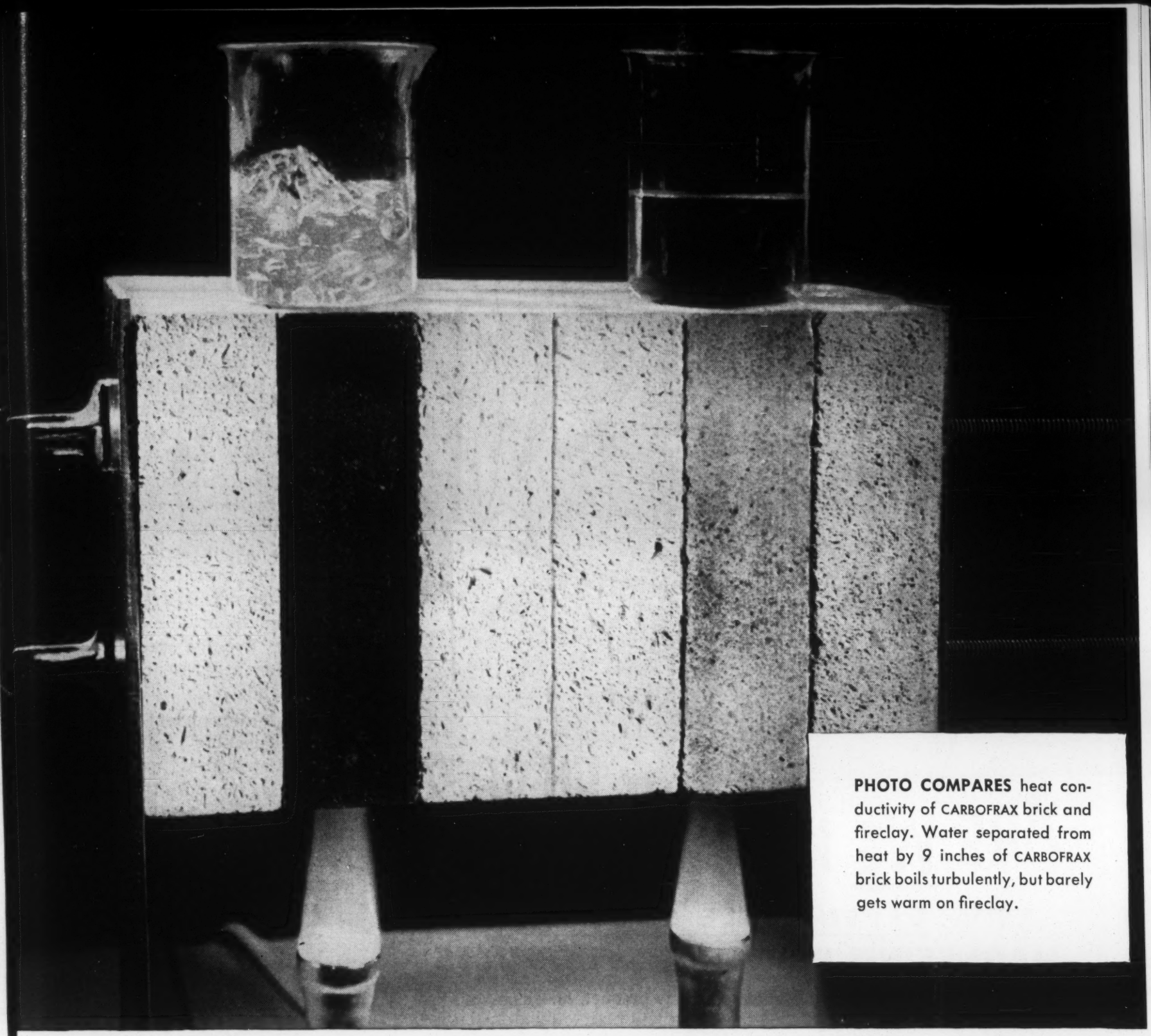


PHOTO COMPARES heat conductivity of CARBOFRAX brick and fireclay. Water separated from heat by 9 inches of CARBOFRAX brick boils turbulently, but barely gets warm on fireclay.

Refractories–for high heat conductivity

High heat conductivity—roughly 11 times that of fireclay and about 70% that of chrome-nickel steels—is one of the properties of CARBOFRAX® silicon carbide refractories. It is an ideal material for muffles, radiant tubes, retorts and similar structures where you need exceptional resistance to direct flame plus the ability to conduct heat efficiently. At 2200°F, thermal conductivity of CARBOFRAX brick is 109BTU/hr., sq. ft. and °F/in. of thickness.

CARBOFRAX refractories typify the many super refractories pioneered by Carborundum. Each has a wide range of properties. One, for example, is formed into precision parts that look like cast iron yet resist over 3000°F. Another, a new ceramic fiber, filters and insulates at temperatures no existing mineral or glass fiber can take.

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Refractories Division,
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Please send me:

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AS A DEPENDABLE SOURCE FOR

MAGNESIUM PARTS AND PRODUCTS

Whether you plan the development of a new product, or are seeking ways to further improve existing ones, you will be interested in the many new avenues which are open to the design engineer who includes magnesium in his basic planning.

Magline Inc.—one of America's leaders in magnesium—has prepared a descriptive new bulletin, expressly outlining for designers and engineers, the company's services as a reliable, experienced source for magnesium castings, fabrication and complete production. Specialists in magnesium exclusively, Magline's background and experience will serve you well in three important ways: (1) Objectively searching out ways to improve your product through the application of magnesium; (2) Assisting in the design and development phases; (3) Producing the required parts and components in any quantity, to your exact specifications. May we send you a copy of Bulletin No. 50.

MagLine

fabrication facilities for

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Design and Engineering Services Available

WRITE TODAY FOR BULLETIN NO. 50. MAGLINE, INC., BOX 411, PINCONNING, MICHIGAN.
CANADIAN FACTORY: MAGLINE OF CANADA, LIMITED, RENFREW, ONTARIO.

For more information, turn to Reader Service Card, Circle No. 423

lock afforded by a one-piece steel collar which is driven into a locking groove on the pin at the point of maximum tension.

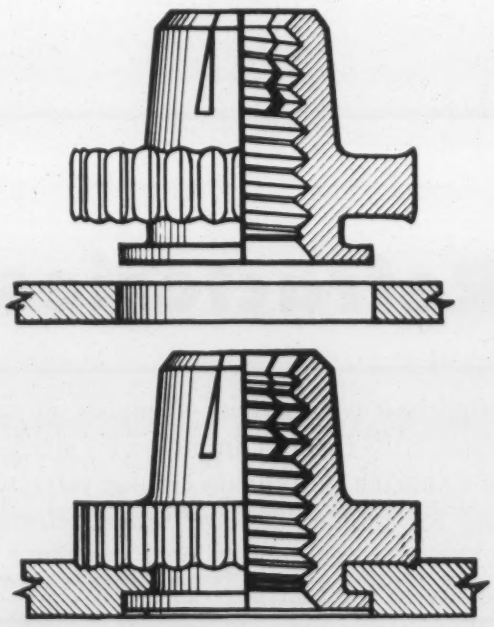
Because of its heat treated alloy steel components the bolt is claimed to afford good shear and tensile strength. An installing tool, available with the fastener, permits fast, easy application by unskilled operators with uniform, high preload results. The close tolerance shank can be driven into an interference fit.

The fastener is available with a countersunk head in grip ranges to meet average requirements. Production at present is limited to ¼ in. dia. size.

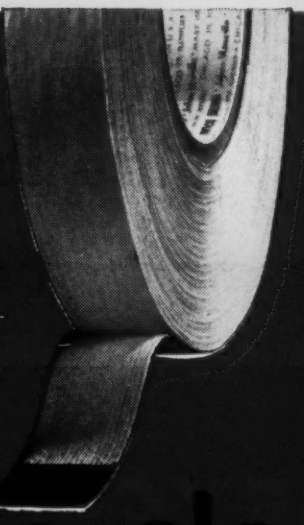
3. For stainless steel

A self-locking feature in a stainless steel press nut available from *Rosan, Inc.*, 2901 West Coast Highway, Newport Beach, Calif., is designed to meet AN-N-5 and AN-N-10 specifications covering locking nuts.

Ranging in thread sizes from 2



How it works. *Smaller flange of press nut (top) is inserted into a hole in sheet metal that has been drilled or punched to a specified diameter. Force is then applied to the exposed edge of the serrated flange. The impact flows the sheet metal (bottom) into a space around the flange of the nut, thus locking the nut into place. The teeth of the serrated flange pierce the parent metal and prevent rotation of the nut.*



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strapping tape

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Dutch Brand Strapping Tape is reinforced with glass strands for superior strength. Now, one man can do strapping jobs by hand . . . and do them fast. Strip, cut, press . . . that's all there's to it.

Dutch Brand's reinforced vinyl backing, with a pressure-sensitive adhesive, makes this tape strong, wear resistant and pliable as only tape can be. It will not snap, tear, sliver or loosen . . . even in dampness, heat or cold. It's waterproof, rot-proof, resists chemicals and oils, will not cut into packaging . . . resists abrasion. Contact your Dutch Brand man today.

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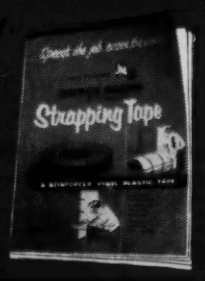

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METALLIC and NON-METALLIC

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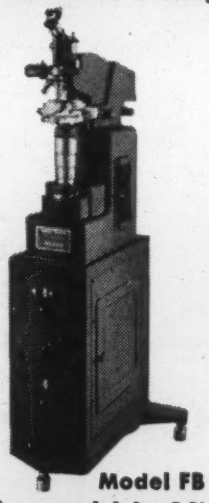
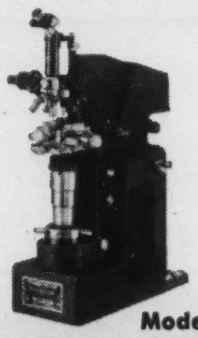
Consult with WILSON Engineers on your hardness testing problem

Experienced WILSON Engineers will be glad to help you select the proper model for your particular requirement. This choice depends on the type and thickness of work to be tested, range of loads and other hardness testing equipment available.

Write for Booklet **DH-328** *on WILSON "TUKON" Micro Hardness Testers. Ask for* **DH-325** *on WILSON "ROCKWELL" Hardness Testers.*



Model FB
Floor model for Micro Hardness Testing only. (Electrically operated)



Model MO
Table model for Micro Hardness Testing only. (Mechanically operated. Also available in floor model)

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through 10, the nut is designed so that it is locked both radially and axially in the sheet metal to which it is attached.

The stainless steel fasteners are also available without the self-locking feature, and a commercial version of the nut is available in Ledloy steel.

Intermetallics Make Good Semiconductors

Rapid progress has been made in the study of silicon and germanium within the past decade and there is now a great interest in other semiconducting materials. Among the more promising types are the intermetallic compounds—a new class of semiconductors chemically different from silicon and germanium. Recent investigations have shown that intermetallic compounds can be made with a wide range of electrical properties, and thus it may be possible to produce more versatile transistors and other semiconductor devices.

In a recent article in the *Bell Laboratories Record*, H. J. Hrostowski discusses these materials which consist of crystal structures of compounds—chemical compounds of two different metallic elements rather than single elements in crystalline form. The most promising of the new semiconductors are the so-called group III-group V compounds. One of the combining elements is taken from group III of the periodic table (three valence electrons per atom) and the second is taken from group V (five valence electrons). These III-V compounds average four electrons per atom and are expected to have many semiconducting properties.

A significant feature of the intermetallic compounds is that by using different combinations of group III and group V elements a wide range of energy gaps can be achieved. A fundamental elec-

JOIN WITH HANDY & HARMAN SILVER BRAZING FOR PERMANENT PROFIT

Joint area is hand-fluxed with HANDY FLUX after which ½" piece of 1/16" EASY-FLO 45 wire is placed on top of joint area. Alloy cost is one half cent per joint.

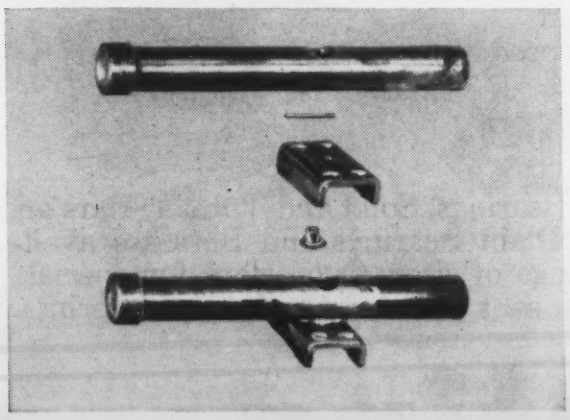
Assemblies are placed between resistance-heating electrodes which serve also as a jig. Operator applies current with foot pedal. Melted EASY-FLO 45 penetrates joint area quickly and easily. Assemblies are then given rapid quench to preserve hardness of cross-slide and to remove HANDY FLUX easily. Time required for complete cycle: 22 seconds. This lady brazes from 1200 to 1500 assemblies per day.

EASY-FLO 45 Solves Problems of Strain and Abuse

In this case, the strain and abuse are centered on the cross-slide joint of a bayonet power saw drive shaft. Made by Wen Products, Inc., Chicago, Illinois, for the do-it-yourselfer as well as the professional, this powerful tool operates at 2650 load strokes per minute and is expected to stand up to considerable strain and abuse throughout its lifetime.

The problem to be permanently solved was that of joining the steel cross-slide piece (.005 case hardened) to the drive shaft. The solution . . . silver brazing with EASY-FLO 45. A simple silver brazed joint assures all the strength this part will ever need. And the people at Wen Products were sure of it when they tested the part in this manner: After brazing, it was placed in a vise and the cross-slide piece was struck at right angles with a hammer. It was completely mangled before it was torn from the shaft. Thousands of these saws are in use today and there is no record of this joint *ever having failed* in service. That says a lot for silver alloy brazing . . . with EASY-FLO 45.

One of the beauties of silver alloy brazing is that it can join a wide variety of metals with the same excellent results and at remarkably low cost. Whatever you are making of metal, whether joints are involved *or not*, it will pay you to investigate EASY-FLO brazing. We will be glad to explain the benefits of simplified design made possible by modern silver brazing techniques —and how these advantages can be profitably applied to your production requirements. Just call us.



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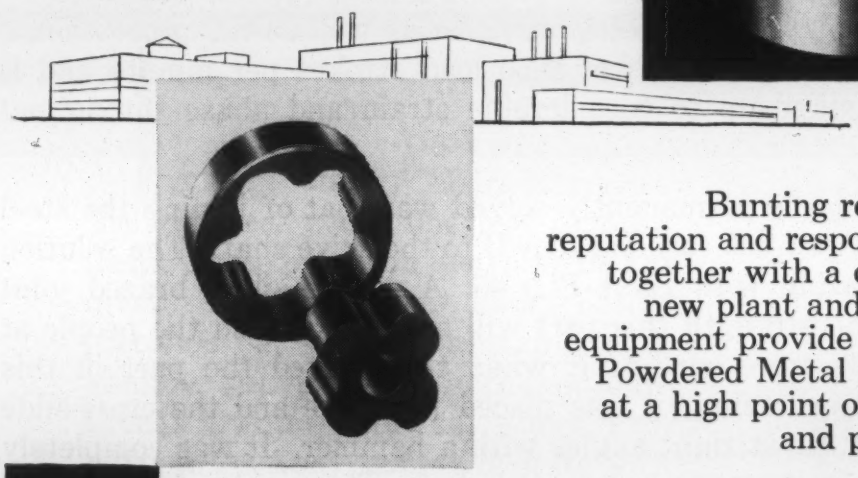

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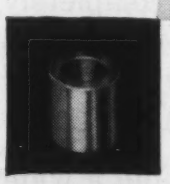

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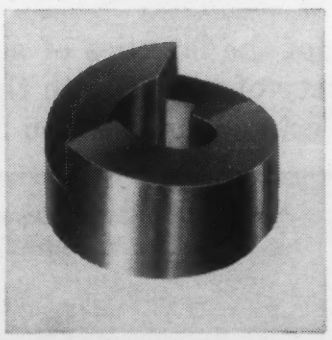

Sintered Plain and Flange Bearings, Solid and Tubular Bars and Thrust Bearings, Cast Bronze Plain Bearings and Bars are available from stock in a wide range of sizes. Quotations for special bearings or special parts will be sent promptly on receipt of prints.

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trical property of a semiconductor is the energy required to free an electron from the bond formed when two atoms share a pair of electrons. When such bonds are broken, electrons become free to travel about in the crystal and thus to conduct electricity. The "hole" left by a departed electron is also considered as a conductor of a positive charge and is similarly free to travel about. The energy required to create an electron-hole pair is called the "forbidden energy gap." This property varies for different semiconductors and is one way of distinguishing among them and of determining how likely they are to be of practical use.

Indium antimonide

An inspection of the periodic table of the elements suggests that many group III-group V compounds exist. Examples are indium antimonide (InSb), gallium arsenide (GaAs) and indium phosphide (InP). Indium antimonide has been investigated most extensively. Although indium and antimony are both metals, the compound is a semiconductor with a cubic crystal structure which would become the diamond structure of silicon or germanium if all the atoms were alike. With three valence electrons for each indium atom and five for each antimony, there is an average of four electrons per atom in the compound. Thus, between each atom and its four nearest neighbors there are four electron-pair bonds. The forbidden energy gap is such that ordinary thermal agitation at room temperature produces 2×10^{16} electron-hole pairs per cu cm. These are free to conduct electricity in an applied field.

Indium antimonide has been purified to such an extent that only one atom in less than ten million is an electrically active impurity. It has been studied at temperatures low enough so that total impurity concentrations have

For more information, Circle No. 544 >

been obtained. Although the energy gap is low (0.17), this material has attracted much attention because of its exceptionally high electron mobility (70,000 cu cm/v sec at room temperature and 1,000,000 cu cm/v sec at liquid nitrogen temperature) which results in a very large change in resistance in a magnetic field. Several devices such as magnetic switches have been based on this effect.

Other intermetallics

Gallium arsenide and indium phosphide have aroused considerable interest because both have energy gaps slightly higher than that of silicon. Electron and hole mobilities also are somewhat higher in these materials. Good rectification has been observed with both compounds. Because of their instability at the melting point, it is difficult to make grown junctions, but it seems certain that new diffusion techniques can produce workable transistors from both compounds.

Aluminum arsenide is similar to these, although most material produced so far is more or less readily attacked by atmospheric water vapor at room temperature and decomposes on standing. Knowledge of all these materials lags behind that of silicon and germanium because of the great difficulties involved in purification and in growing single crystals.

Energy gaps of intermetallic compounds range from a few tenths of an electron volt to several electron volts. Compared to 0.75 e.v. for germanium and 1.1 e.v. for silicon, there are a number of semiconducting materials with a wide range of energy gaps, such as 0.17 e.v. for indium antimonide and 2.2 e.v. for gallium phosphide. The author contends that in the foreseeable future it will be possible to select a "tailor-made" semiconductor suitable for a particular application.

(more What's New on p 179)

NEW IMPROVED HARD FACING

Tough, hard ceramic coatings provide superior bearing surfaces

Sprayed alumina forms "sapphire-hard" surfaces highly resistant to wear, abrasion and corrosion. Ideal for bearing surfaces, seals.

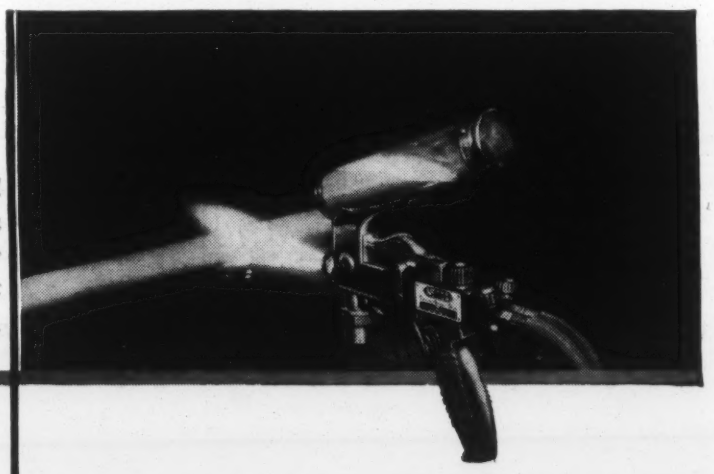
Development of the new METCO THERMOSPRAY GUN for spraying high-melting-point ceramic materials at low cost opens up a variety of new practical applications. One that has produced a great deal of interest is the use of sprayed alumina coatings for bearing surfaces and mechanical seals. This THERMOSPRAY 101 Ceramic Powder produces surfaces with a hardness of 9.0 on the Moh scale, (only the diamond rates 10.0) with excellent resistance to wear, abrasion and corrosion. When used in combination with special phenolic or furane plastic sealers it provides superior protection against many acids.

Another THERMOSPRAY Powder – 201 – is zirconia which is somewhat softer than No. 101 but provides superior heat-insulating properties. Melting point of this material is 4600° F. and particle hardness 8.0 on the Moh scale.

Hard-facing alloys of the self-fluxing, nickel-boron-silicon type in powder form can also be applied with the METCO Type P THERMOSPRAY GUN. These coatings may be fused, semi-fused, or left unfused depending on the hardness desired, from RC 30 to RC 65, depending on the alloy and the process used.

The new THERMOSPRAY GUN operates without compressed air, only oxygen and acetylene being required. The free-flowing THERMOSPRAY powders are fed to the flame nozzle from a hopper atop the gun, melted and propelled to the surface to be coated. These materials are sprayed many times faster (up to 15 sq. ft. per hour – .010" thick) than has been possible with equipment previously available. Deposit efficiencies are in excess of 95%. These factors result in extremely low coating costs.

Preliminary engineering data contained in Bulletin 127 covers ceramic coatings while Bulletin 126 covers the hard-facing alloys. Either or both may be obtained by filling out the coupon below or writing on your company's letterhead. No obligation, of course.



Pump rod sprayed with alumina provides superior protection against abrasion and corrosion.

spray ceramic coatings at high speed with high deposit efficiency
the THERMOSPRAY PROCESS
for spraying alumina-zirconia-other high temperature ceramics

free bulletins
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Please send me ☐ free Bulletin 127 (ceramic coatings)
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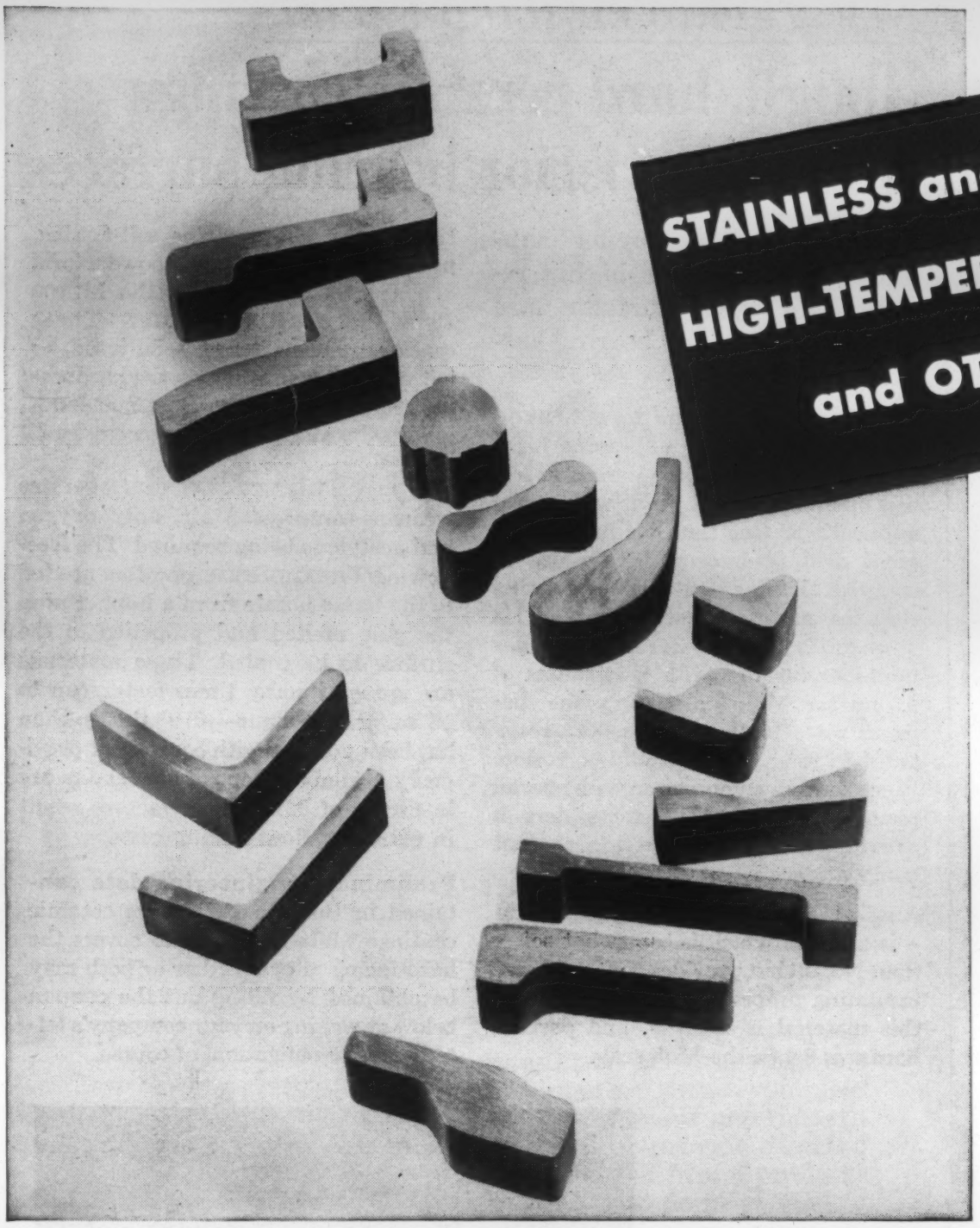

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● We're ready to serve your needs with hot extrusions in any grade of stainless or high temperature steel, many tool steel grades and other steels. Call us in to help. *Allegheny Ludlum Steel Corporation, Oliver Building., Pittsburgh 22, Pennsylvania.*

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AL STAINLESS STEEL

WSW 6318A

For more information, turn to Reader Service Card, Circle No. 499

What's new IN MATERIALS

Nonsticking Rubber

A rubber compound that is reported to have excellent nonsticking characteristics has been developed by *Goshen Rubber Co., Inc.*, Goshen, Ind. Designated Compound No. 1318, the rubber can be quickly removed from another material without prelubrication. It can be used from -40 to 300 F. Recommended for valve seat and similar applications, the material is said to bond well to metals.

Electrodes, Fluxes, Other Joining Products

Following is a summary of new developments in welding electrodes, fluxes and related products.

1. Organic flux

Alpha Metals, Inc., 56 Water St., Jersey City 4, N. J., has announced an acid and rosin free type flux for use in nonelectronic applications. The organic flux is said to be free from zinc and ammonium chloride and other inorganic salts that cause excessive corrosion.

It is recommended for use on copper, brass, bronze, steel, nickel, and stainless steel (300 series) and is available in single cored form. It can be supplied in all of the usual tin-lead alloys, as well as pure tin and other special alloys.

2. Copper solder fluxes

Noncorrosive, quick-wetting solder fluxes, designed primarily for use on copper and copper base alloys, are now being manufactured by ***Federated Metals Div.***, *American Smelting and Refining Co.*, 120 Broadway, New York 5, N.Y. They contain derivatives of hydrazine and are known as the H-Series Solder Fluxes.

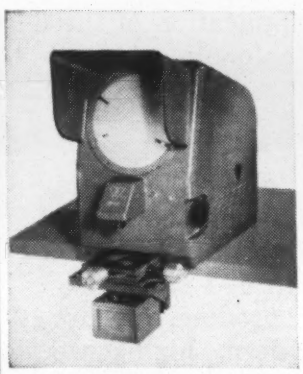
It is claimed that the fluxes promote solder spread over a wide range of temperatures more effectively than conventional zinc

PRECISION PRODUCTION PROBLEMS ?

Here's help from Bausch & Lomb in TOOL DESIGN INSPECTION FABRICATION MEASURING TESTING

NEW! ALIGNMENT INTERFEROMETER

Accurately measures small changes in angle over a range of 30 seconds of arc (±15 seconds). Easy direct scale readings to 0.2 seconds (0.000006″).



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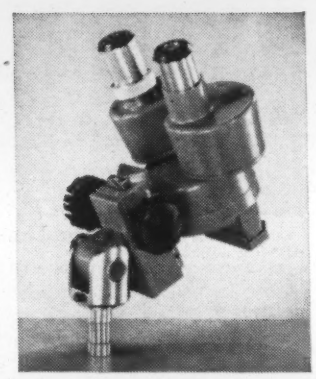
Exclusive understage illumination—no complex set-ups, no holding fixtures for most work. Magnified silhouettes show errors instantly. Reads to 0.0001″ with optional micrometer stage.



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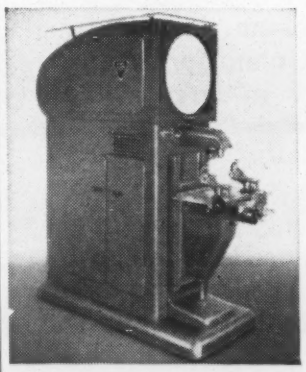
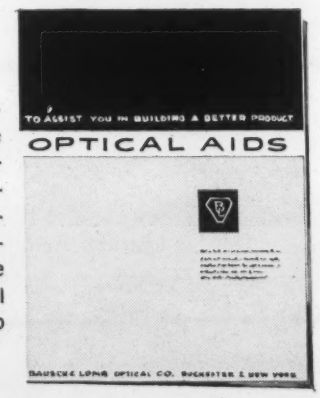
Magnified 3-D views of tiny parts. Dustproof, shockproof, can be mounted right in machine or fixture. Speeds assembly, inspection. Most complete line, widest field of view.



CONTOUR MEASURING PROJECTOR

Shows magnified silhouettes or surface views. Simple operation, highest precision measurements: to 0.0001″, linear; to 1 minute of arc, angular.



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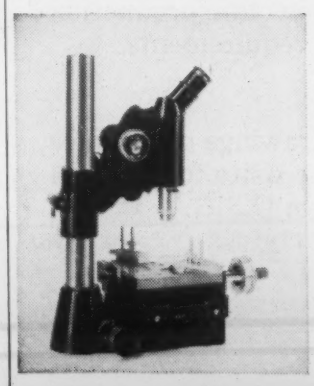
Time-and-money-saving data on Surface Comparators, Industrial Magnifiers, Macroscopes, Microscope Bodies, Micrometer Discs, Wide Field Tubes, Brinell Microscopes, Shop Microscopes.



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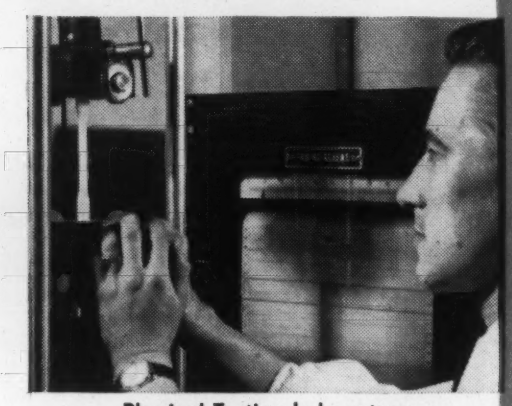
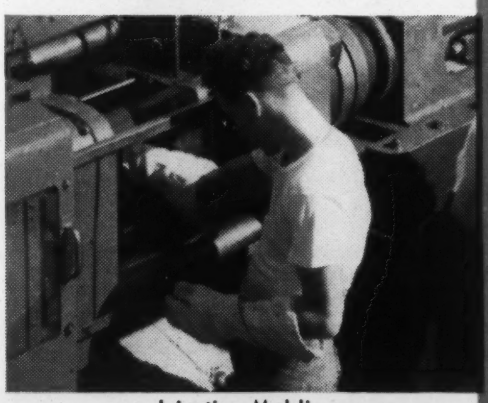
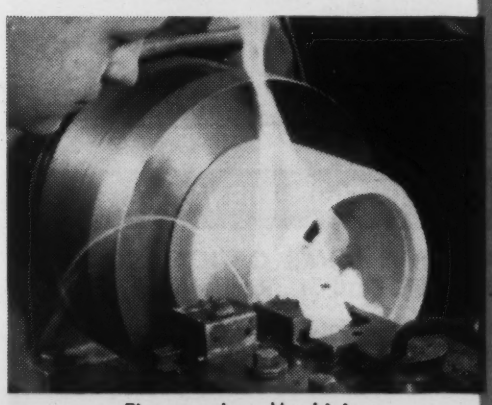
Electronics Test Cage



Physical Testing Laboratory



Injection Molding



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Today, this company offers engineering and manufacturing talent and facilities unmatched in the industry to assist its customers in the profitable application of these and other plastics for almost countless purposes.

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Hence, we not only provide for the manufacturer's needs at the prototype and limited production stages of his product—but supply the answer to the most efficient method, and an accurate yardstick of cost-measurement, in the production of his ultimate requirements.

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*du Pont's trademark for its tetrafluorothylene resin.
†Kellogg's trademark for its trifluorochloroethylene resin.

UNITED STATES GASKET CO.

CAMDEN 1, NEW JERSEY

For more information, turn to Reader Service Card, Circle No. 466

What's new IN MATERIALS

ammonium chloride fluxes. They are said to be especially well adapted to operations where both flux and solder are preplaced and heat applied automatically.

The noncorrosive fluxes are effective with special solders, like silver lead eutectic, melting at 580 F. No washing or cleaning of metal surfaces are said to be necessary with their use. Other metals like steel, aluminum, zinc and stainless steel can be soldered with the fluxes if they are first coated or plated with copper, tin, solder or silver.

3. Iron powder electrode

An iron powder electrode for welding mild and galvanized steels has been introduced by *Metal & Thermit Corp.*, 102 E. 42nd St., New York 17, N.Y.

Called Speedex U, the electrode can be used in all welding positions on any type of current at high amperages. The electrode has light spatter and operates with a quiet, moderately penetrating and easily directed arc.

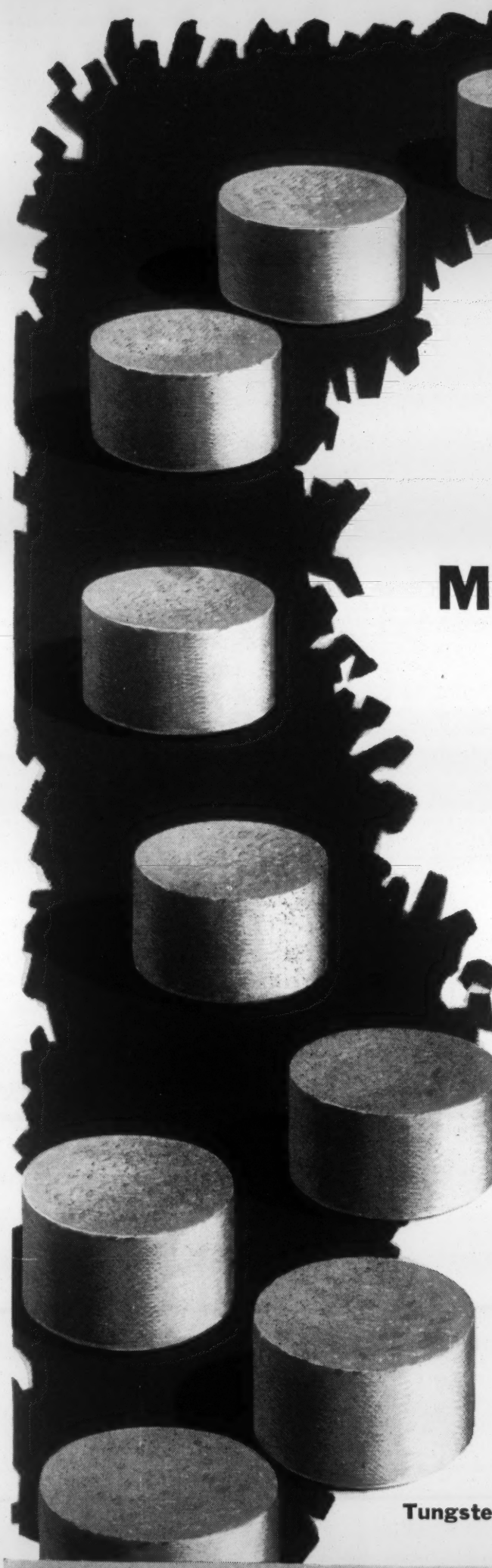
4. Hard surface flux

A dry type welding flux for use when applying nickel and cobalt base hard facing alloys to iron- and nickel-base alloys containing chromium, titanium and/or aluminum is available from *Wall Colmonoy Corp.*, 19345 John R St., Detroit 3, Mich.

Said to contain salts that do not produce a glare, the flux, called Colmonoy Flux 6-20, imparts good flow characteristics to hard facing alloys. It may also be used on cast iron parts.

5. Silicone weld cleaner

Chipping, grinding, and other time-wasting cleanup operations that follow arc welding are said to be eliminated by a new silicone-containing emulsion called Linde X-7 Anti-Spatter. Introduced by *Linde Air Products Co., Div. of Union Carbide and Carbon Corp.*, 30 E. 42nd St., New York 17, N.Y., the emulsion is applied to the spatter area before arc welding



NEW
from Sylvania
High purity
MOLYBDENUM PELLETS
for vacuum melting

If you are a producer of high creep strength alloys or high-temperature super alloys, you will find that Sylvania's molybdenum pellets have the characteristics you need to meet exacting specifications.

Sylvania's molybdenum pellets are controlled to a 99.5 per cent minimum purity, with a typical purity of 99.85 per cent. Gas content is kept low by maintaining a maximum density. Pellets (1″ in diameter by ½″ thick) make it easy to calculate additions and charge to the melt.

Pelletized molybdenum offers obvious advantages over scrap in alloy production. Unit costs are constant. Reproducibility of results is assured. High purity and low gas content make it easier and less costly to meet rigid production specifications.

Also available from Sylvania is high-purity tungsten, in sintered ingot form, suitable for vacuum melt alloying.

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If you're suffering from tired metals, weak metals, corroded metals—or some other costly metal ailment—it will pay you well to put in a call to a metals specialist today. May we suggest Riverside? Our metallurgists *are* specialists. And Riverside's experience in non-ferrous alloys spans more than a century. Experience, incidentally, that is yours for the asking.

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H. K. PORTER COMPANY, INC.

For more information, turn to Reader Service Card, Circle No. 478

What's new IN MATERIALS

to form a protective coating over the metal. The coating prevents molten spatter from sticking to the metal and enables an operator to remove spatter with a cloth or spray after welding.

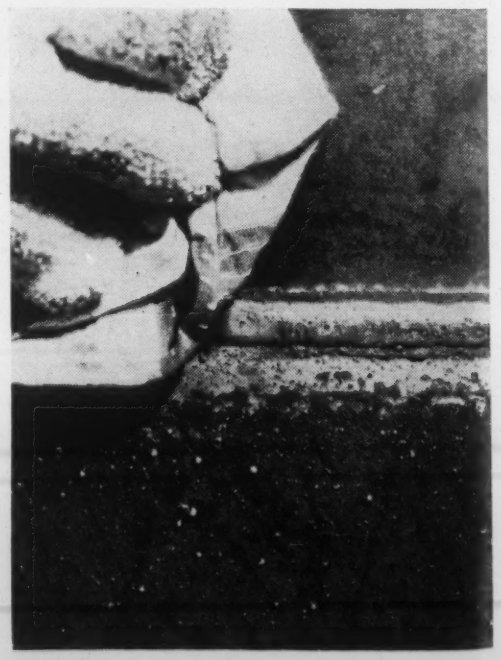
The basis of the emulsion is silicone, said to be the first application of this material as an anti-spatter agent. The emulsion is nontoxic, nonflammable and can be used on any metal without affecting weld quality. It costs less than 1¢ per sq ft of treated surface in normal arc welding operations. It can be applied weeks before welding.

6. Pipe welding electrode

An electrode called Fleetweld 5-P, designed especially for pipe welding, has been announced by *Lincoln Electric Co.*, 22777 St. Clair Ave., Cleveland 17, Ohio.

The electrode produces a flat-shaped bead in an even deposit and also provides minimum slag interference. In pipe welding the electrode gives smooth arc operation, deep penetration, and good bead wash-in.

It is recommended for pressure vessels, x-ray applications, structural welding, machinery weldments and ship welding. It is available in 1/8 and 5/32 in. dia.



***Removing** weld spatter from metal that has been treated with a silicone-containing anti-spatter compound.*

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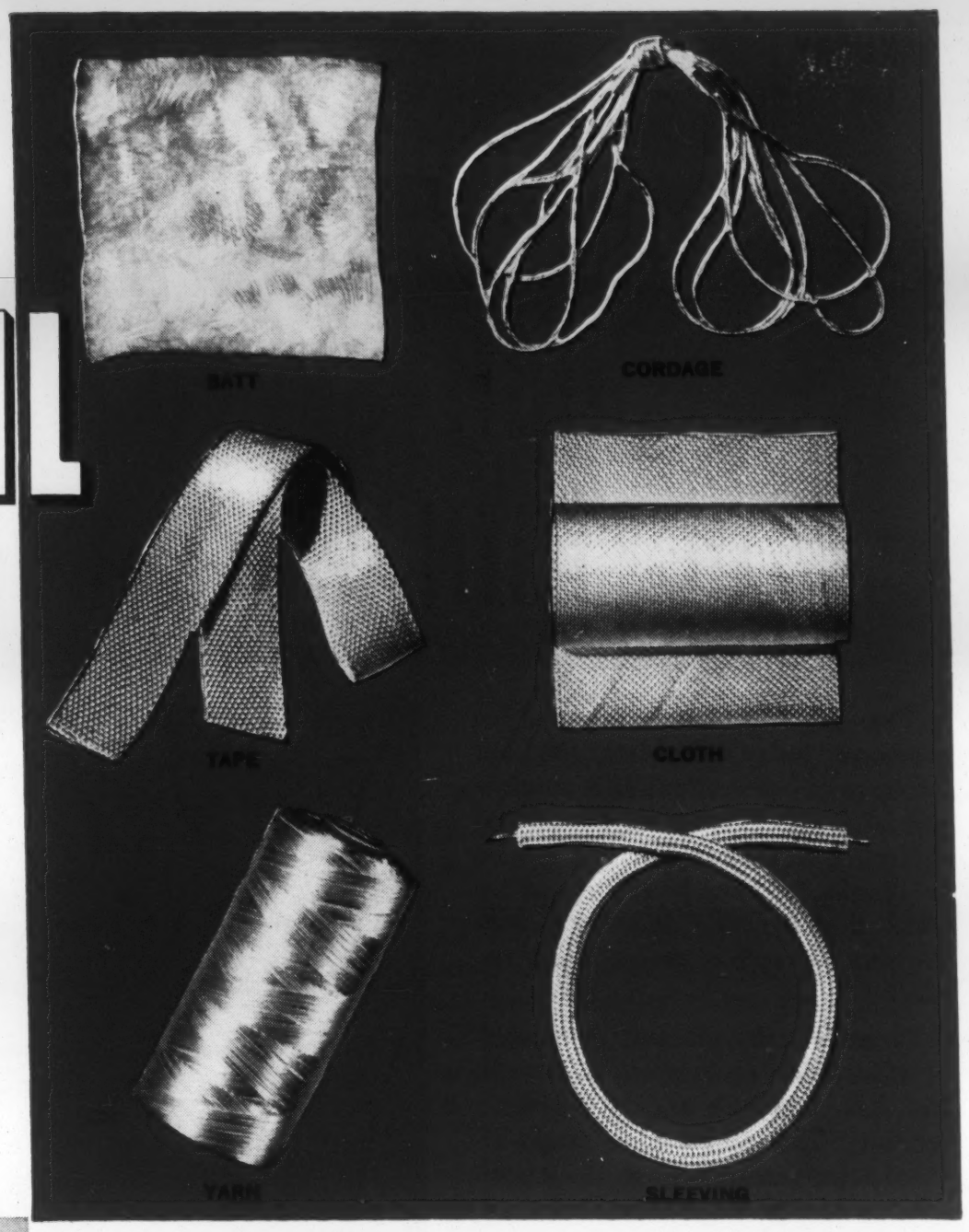
2000°-3000° F.
High Temperature Insulation

...it may be the special insulation you've been looking for!



REFRASIL PROPERTIES:

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- Fiber diameter .00020—.00040 in.
- Specific heat .19
- Thickness .14—.15 in.
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For more information, turn to Reader Service Card, Circle No. 426

JANUARY
1957

Plastiatrics

DOW'S CLINICAL APPROACH TO HEALTHY PLASTICS APPLICATION

DOW

HIGH SPEED MOLDING OF THIN WALL CONTAINERS

The high potential for molded packages today pinpoints the importance of automation. This requires special knowledge by engineers and designers. At Dow, continuing studies in Plastiatrics have been directed toward this dynamic industry's fast-growing concepts of design and manufacture.

To achieve the economy demanded of expendable containers, thin walls less than .030 inch are an economic necessity. The technological target of Plastiatrics research is the practical solution of difficult problems inherent in such injection molding.

Understanding of fundamental considerations, both in theory and in practice, is essential. Behavior of polystyrene materials throughout the molding system has been carefully documented at Dow. Photographic studies within the mold make it possible to anticipate, and hence, reduce areas of resistance, compression and stress. Orientation characteristics must be recognized to avoid directional loss of physical properties. Molding equipment and procedures must be selected with care to insure maximum possible output speeds. The refinement of injection molding principles, in sum, makes possible a scientific approach to the problems of automation. Better packages of higher quality will be the result.

Whatever the design, successful use of the finished product is the final test. To achieve the uniformity and high quality demanded by automation, the Styron® family of polystyrenes is carefully formulated and field tested. Plastiatrics is the scientific approach to the satisfactory application of plastics in the processes and uses required by competitive production engineering. Your nearest representative will be glad to furnish a summary of Dow products and services.

AUTOMATION OF THIS INJECTION MOLDING PRODUCTION LINE FOR VENDING MACHINE CUPS IS A MILESTONE IN THE DYNAMIC GROWTH OF PLASTICS MANUFACTURING.

WRITE FOR TECHNICAL BULLETIN

For a more detailed report on the molding of thin-walled containers, ask for Plastics Technical Service bulletin—"The Technology of Injection Molding, VIII, Thin Sections". Look for the findings of continuing Plastiatrics research in these pages regularly. THE DOW CHEMICAL COMPANY, Midland, Michigan . . . Plastics Sales Department PL 436H.

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- STYRON 666
- STYRON 665 (Extrusion)
- STYRON 688 (Easy Flow)
- STYRON 689 (Easy Flow)

HIGH IMPACT
- STYRON 475
- STYRON 429 (Extrusion)
- STYRON 777 (Medium Impact)
- STYRON 440 (Heat Resistant)
- STYRON 480 (Extra High Impact)

HEAT RESISTANT
- STYRON 683
- STYRON 700

YOU CAN DEPEND ON DOW

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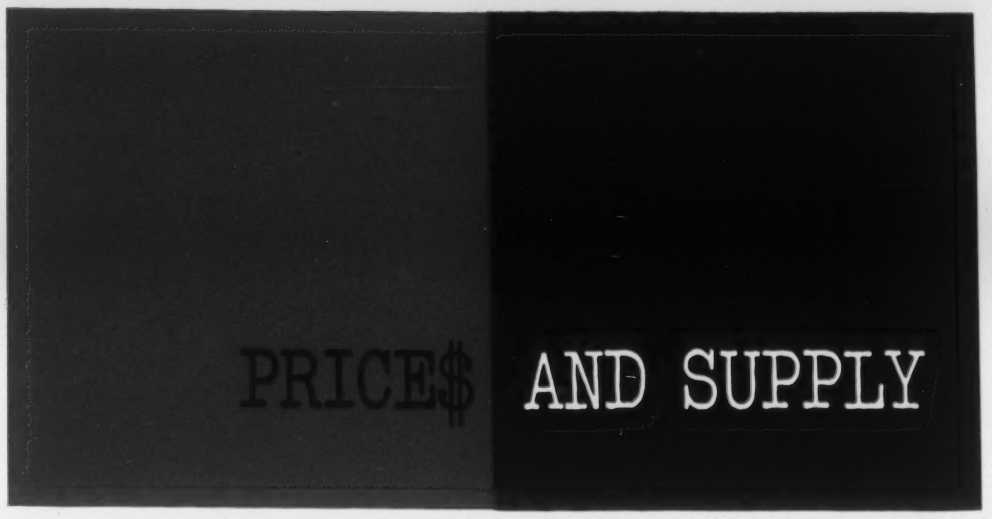


The Outlook

by Herman B. Director, *Consultant, Washington, D. C.*

Steel shortage will continue

A shortage of most steel products has resulted from a series of factors, including work stoppages in the summer of 1956, sustained demand and the international situation, as well as the work stoppages on the docks. The shortage of plate, structural and petroleum industry goods, such as pipe, bits, sucker rods, etc., will continue for some time. What is now a clear trend in the automobile sales pickup will result in renewed pressure on flat rolled products. The average new car is using from 50 to 100 lb more steel than last year's models. Galvanized products also are in strong demand. Mills operating at capacity levels are hard pressed to meet demand.

Steel prices will rise

Price increases in many of the ferroalloys, especially ferro-manganese, as well as other materials used in making steel, point to a further increase in the price of steel beyond the levels established after the summer strike. The Government's action in turning down the industry's request for over one billion dollars of rapid tax amortization, coupled with industry's depreciation experiences, add more pressure to industry's demand for an increase in price. One major steel producer estimates that the cost of a new facility at a new site would be about $350 per ton, compared with $80 per ton if the new capacity is added to an existing facility. The only remaining price increase question is when and how much.

Copper not likely to get cheaper

World copper output, including U. S. domestic production, is at an all-time high. Inventories are higher than at any time since 1954. In spite of the excess supply, domestic prices are being maintained at the current levels. There is virtually no prospect that producers will offer forward commitments at a fixed price over any long period of time. Nor does it look as though efforts to stabilize the London market will succeed. This has been tried before at substantial cost to those who tried.

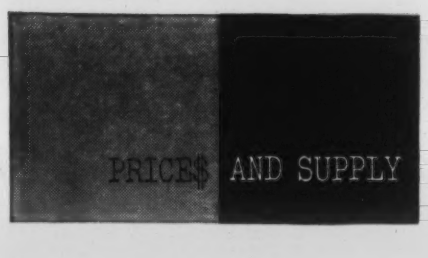
The price policy of domestic producers is to some extent affected by the attitude of the Chilean Government. It is well known that the Chilean Government budget depends upon a price of at least 36¢ per lb for copper. Any reduction below this price would pose difficult decisions for copper producers, especially those who operate properties both in the United States and Chile.

Aluminum: still enough to go around

Aluminum supplies are adequate although not as fully adequate as producing companies indicate. Any increase in demand over current levels would create a pinch in the market. The new 1957 automobiles have increased aluminum consumption but are still far below the 300 lb per car figure which the more optimistic people in the aluminum industry forecast as a possible level. The average car carries about 50 lb of aluminum, as compared with 35 lb in 1956 and 25 lb in 1955. An increase to 300 lb per car could mean an average increase of $100 in the price of a car. The resale value of aluminum-trimmed cars has not yet been proved.

New steels won't ease nickel shortage

Nickel-bearing products will continue in short supply. Series 300 chromium-nickel stainless in mill quantities will be hard to get. The new 4% nickel 200 series and Type 430 non-nickel-bearing grades are more readily available alternates and are excellent for many applications. However, releases by the Department of Defense indicating that 10% of total nickel consumption could be saved by industry using the 200 series do violence to the arithmetic. A 10% savings would mean about 25 million lb, or 50% of the total consumption of stainless steel, including defense production. At the outside, diligent application of the 200 series in the immediate future



The Outlook—continued

might conserve 2 or 3 million lb of nickel.

The steel industry will produce during 1957 an estimated 540,000 tons of nickel-bearing stainless steel, compared with 450,000 tons in 1956. The industry is expected to produce about 30,000 tons of 200 series steel in 1957, compared with 15,000 tons in 1956.

Suez inflates rubber and tin prices

Blocking of the Suez Canal has affected natural rubber in two ways: increased shipping time, and increased prices due both to market conditions and to increased shipping costs. From different directions the Government is being urged: 1) to release material from Government stocks and increase domestic production quotas for shipment overseas, 2) not to release materials from Government stocks, 3) to remove quota restrictions in order to maintain a firm price in the market. The Government's action will probably be based upon the effect of United States action on foreign policy rather than on domestic market conditions.

The increase in world supply of tin which would have resulted from the closing of the Texas City tin smelter has been nullified by the blocking of the Suez Canal and the general increase in demand. As a result, tin prices are at a higher than expected level.

More germanium

The increased emphasis on germanium in electronics applications will be helped by an expansion of germanium supplies in Africa and Rhodesia. Germanium is normally a by-product of zinc refining.

Supply of mercury improves

The market pinch on mercury which was in evidence last year has abated considerably, thus relieving both the pinch on supply and the upward pressure on prices. The impact of increased atomic energy demand seems to have been pretty well absorbed.

Plenty of flat glass

Expansion of production facilities in the flat glass industry, which amounted to well over a quarter of a billion dollars during the past ten years, plus the unusually heavy import volume in the past year, has enabled that industry to more than keep pace with demand. Consequently, there should be no shortage of flat glass in 1957. Industry estimates indicate a 3% increase in glass container shipments over 1956.

Plastics: larger supply, lower prices

Statistics on the production and sale of plastics over the past several years are normally cited as indications of the amazing growth of the plastics industry. Another sure sign of the direction in which the industry is moving may be seen from the continued expansion of the industry three years after the Government's accelerated tax amortization expansion goal on plastics materials was closed. Polyethylene and polyvinyl chloride, in particular, will undergo considerable expansion this year.

So far as prices are concerned, important plasticizers are feeling competitive pressures and should go down in price. Polyethylene has already felt the impact of price reductions. Selenium prices, in the face of more adequate supply, should also come down; European countries normally importing from the United States are now offering selenium for sale in this country.

More oxygen on the way

Supplies of oxygen are also scheduled for 50% expansion, although there will continue to be a pinch in coming months. Large-scale increase in industrial uses of oxygen caught the oxygen industry pretty much unprepared to meet the demand. The expanded facilities will be high purity gaseous oxygen units, most of which will be for steel mill and other metallurgical operations.

Lead and zinc prices still propped

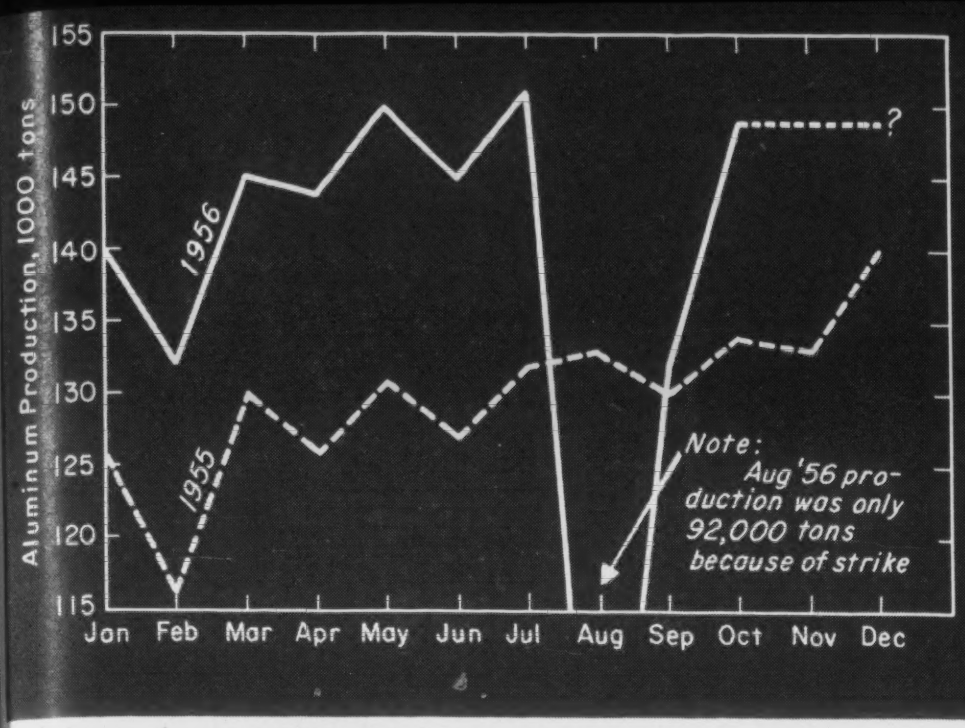
U. S. Government barter transactions continue to support the world price of lead and zinc. Even though demand for die castings and peak demand for galvanized products keep the market somewhat firm, the price would probably be a cent or two lower without interference from barter transactions.

Alloy restriction off at last

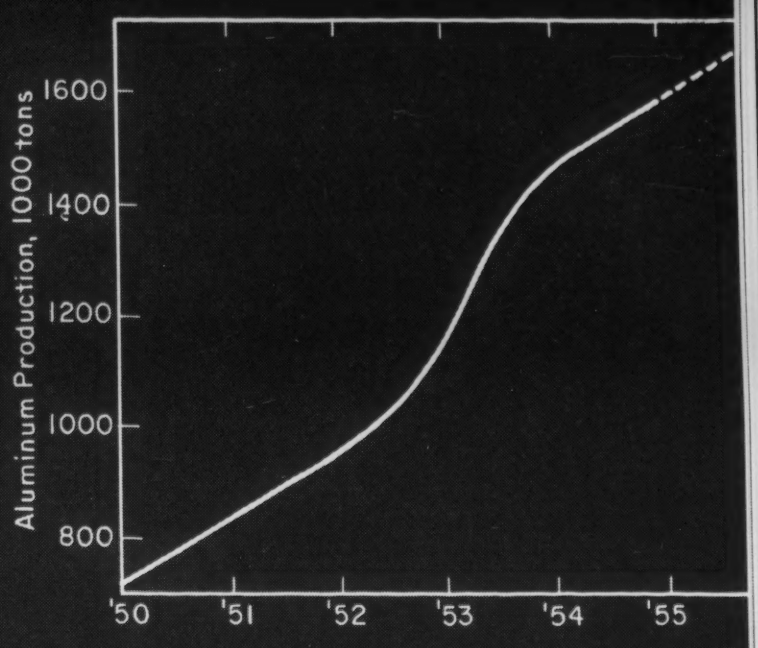
The Department of Defense has removed the quantitative limitation on the use of alloying materials such as nickel, columbium, cobalt and tungsten, especially in jet aircraft. Actually, tungsten, columbium and cobalt are more nearly a glut on the market than scarce. This action could have been taken by the Department of Defense several years ago.

Cheap leather thanks to dogs?

A new project, if successfully accomplished, could eventually ease the price of leather. Serious attempts are being made to find additional markets for hides, skins and animal by-products. A newly appointed task group, organized under the President's Bipartisan Commission on Increased Industrial Use of Agricultural Products, is proceeding in high gear. For example, consideration is being given to the use of hide fleshings for dog food in view of the substantial decline in the number of horses available for this purpose.



Monthly comparison *of aluminum production for the years of 1955 and 1956.*



Growth *of aluminum production from 1950 to 1956.*

Aluminum Production to Double in 10 Years

■ Production of primary aluminum in the United States during the month of October amounted to 149,127 tons, according to figures released by the Aluminum Assn. Although slightly below the all-time monthly high of 151,524 tons registered last July, the figure represents an increase of more than 10% compared to production in October of last year. So, not only has the aluminum industry completely recovered from the recent strike (note sharp decline in chart), but it is also likely to achieve and surpass its estimated goal of producing at least 110,000 tons more than in 1955. As of the beginning of November the total increase over last year amounted to 94,500 tons.

Balance between supply and demand is the best it has been in many months, and it is expected to grow even better in the months to come. I. W. Wilson, president of the Aluminum Co. of America, predicts that annual production of aluminum will be about 3,000,000 tons by 1958, and that "the simple economic facts" are that the industry will produce more than will be demanded. However, Mr. Wilson feels confident that with markets expanding this situation would not last long.

Bert Inch, vice president of Kaiser Aluminum & Sales, expects usage of aluminum in the next ten years to double, or even triple in some areas. In order to meet the expected rise in demand, he says, the aluminum industry has scheduled the expenditure of more than $600 million to increase capacity of 18 new and existing plants by more than 900,000 tons. In addition, the industry is spending more than $400 million for expansion of facilities for producing wrought products. These expenditures will add a total of nearly 650,000 tons to existing mill capacity. Mr. Inch breaks down the projected capacity as follows:

Sheet and plate—$264 million by ten companies to add 450,000 tons of capacity; extruded products—$66 million by six companies to add 63,000 tons; foil—$57 million by four companies to add 44,000 tons; rod, bar and wire—$8 million by two companies to add 23,000 tons; and forgings—$8 million by three companies to add 5500 tons.

(more news on p 195)

M&M's Prices Page

The prices page that follows (p 188) is our first effort in this direction. In future months we will expand our prices coverage in two ways: 1) we will cover a broader range of materials, and 2) we will cover each group of materials in more detail.

Now and in the future, however, it is important to be fully aware of the natural limitations of any such prices page. First, our prices are deliberately approximate, since they are intended to show the general price level, not spot purchase prices. Second, our prices can never take into account all of the possible variations due to size, color, quality, finish, packaging, location and delivery time. Third, when important price changes occur, our prices may be obsolete for as much as a month because of our monthly publication deadline.

All of these limitations, however, serve to emphasize our primary purpose in providing this prices page: to make it easier for you to make fairly specific economic comparision of engineering materials. In short, the M&M prices page is intended not for the purchasing agent, but for the engineer who selects and specifies engineering materials.

PRICE$ AND SUPPLY

Prices of Materials

NONMETALLICS

Prices for large quantities for range of grades, color, sizes; given in $/lb

THERMOPLASTICS

Material	Molding Compounds	Sheet (.030-.250in.)	Rod		Tube	
			⅛-¼ in.	⅜-1¼ in.	⅛-¼ in.	⅜-1¼ in.
Acrylic	.51-.59	.49-2.15	.90-1.15	.80-.90	1-1.15	.90-1
Cellulosic						
Acetate	.36-.65	.92-1.16	.75-1	.65-.75	.85-1	.75-.85
Butyrate	.50-.72	1-1.28	.95-1.20	.85-.95	1.05-1.20	.85-1.05
Nitrate	—	1.60-2.73	1.45-1.75		2.25-5.00	
Propionate	.51-.63	—	—		—	
Fluorocarbon						
PTFCE	7-12	15-23	18-22		20-22.50	
PTFE	4.50-7.45	14.30-11	13		13	
Nylon	1.35-2.30	—	3		3	
Polyethylene	.37-.56	.85-1	.75-1	.65-.75	.85-1	.75-.85
Polystyrene	.27-.44	.57-.61	.65-.90	.55-.65	.75-.90	.65-.75
Vinyl	.27-.43	.62-.92	.75-1	.65-.75	.85-1	.75-.85

RUBBER

Material	Dry	Latex
Butadiene-Acrylonitrile	.49-.65	.46-.59
Butadiene-Styrene	.17-.30	.26-.32
Butyl	.23-.28	—
Neoprene[a]	.39-.75	.37-.47
Silicone[a]	1.90-4	—
Polysulfide[a]	.47-1	.70-.92
Natural	.37	—

[a]Less than carload quantities.

THERMOSETTING PLASTICS

Material	Molding Compounds	Laminating, Casting Resins
Alkyd	.34-.53	—
Epoxy	—	.45-.80
Melamine	.42-.45	.40-.41
Phenolic	.20-.40	.17-.34
Polyester	—	.32-.50
Silicone	2.75-5.40	1.55-1.74[a]
Urea	.19-.33	—

[a]60% solids content.

IRONS AND STEELS

Mill base prices for large quantities

STAINLESS STEELS (¢/lb)

Material	Ingots	Forging Billets	H. R. Bars	Plate	Sheet, Strip
Austenitic					
301, 302, 302B, 303, 304, 305	21-25	34-38	41-44	43-46	44-54
321	28	42	50	55	60
347	33	50	59	64	73
Martensitic					
410	16	27	33	34	39
416	—	28	33	35	47
403	—	31	36	39	47
420, 440	—	33	40	44	60
Ferritic					
405, 430, 430F	16-19	28-29	33-34	35-36	39-50
442	—	32	38	40	54
431	—	36	42	44	53
446	—	38	45	46	67
High Manganese					
202	21	33	39	41	45
Extra-low Carbon					
304L	—	44	51	53	58
316L	—	64	74	78	82
Precip Hardenable					
17-7PH	—	55	65	72	77-82

IRON ($/gross ton)

Pig	62.50-63.50

SEMIFINISHED STEEL ($/net ton)

Ingots, Alloy	74
Billets, Blooms, Slabs	
Carbon, Re-rolling	74
Carbon, Forging	92
Alloy, Forging	107
Seamless Tube Rounds	112
Wire Rods	$5.85/cwt

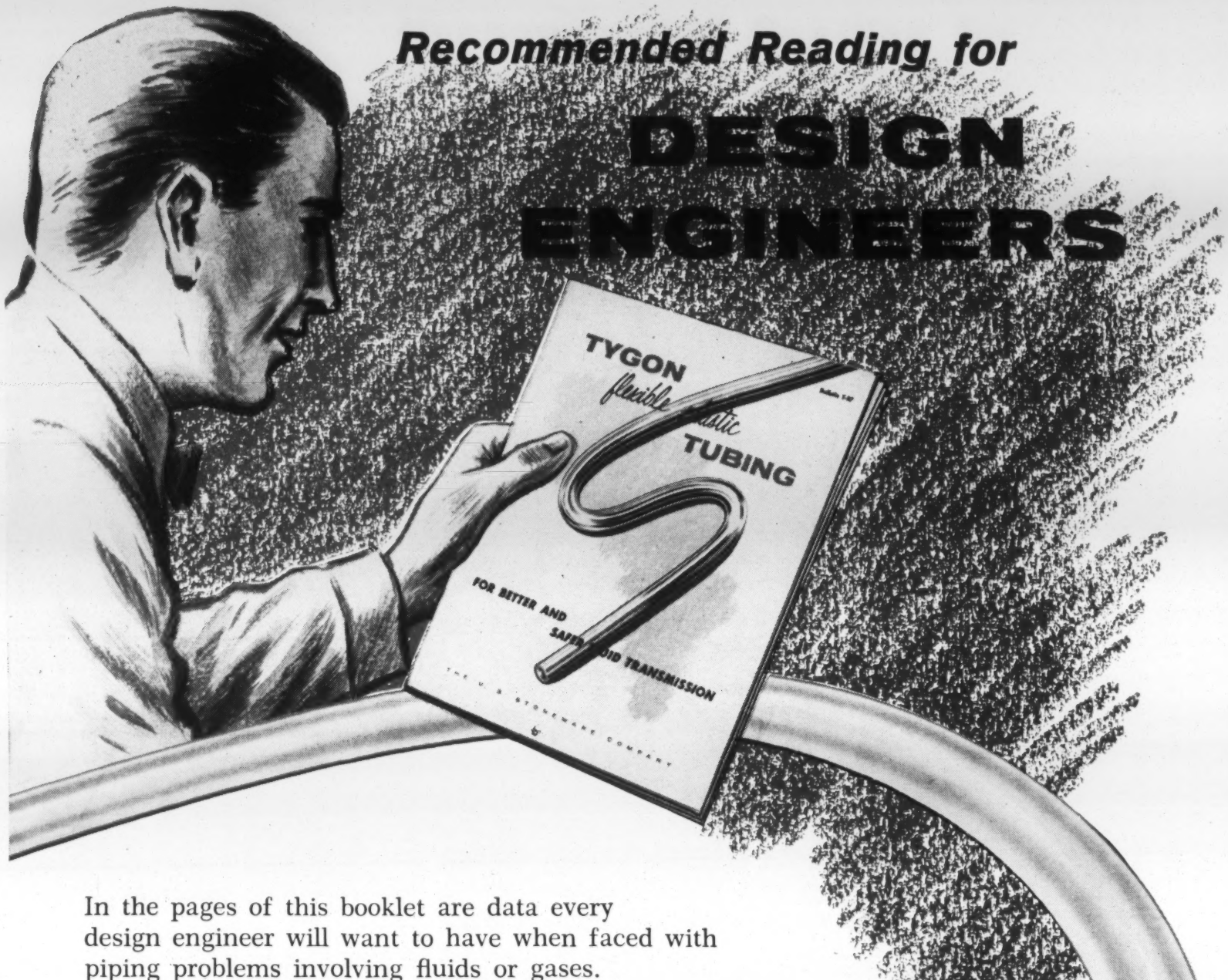
FINISHED STEEL ($/cwt)

Form	Carbon	High Str Low Alloy	Alloy
Plate	4.85	7.25	6.85
Sheet, H.R.	4.65	6.90	—
Sheet, C.R.	5.75	8.50	—
Strip, H.R.	4.67	6.95	7.75
Strip, C.R.	6.85	10	14.55
Bar, H.R.	5.05	7.40	6.10
Bar, C.F.	6.85	—	8.30

All prices are approximate and given solely for the general guidance of those responsible for materials selection.

Recommended Reading for

DESIGN ENGINEERS



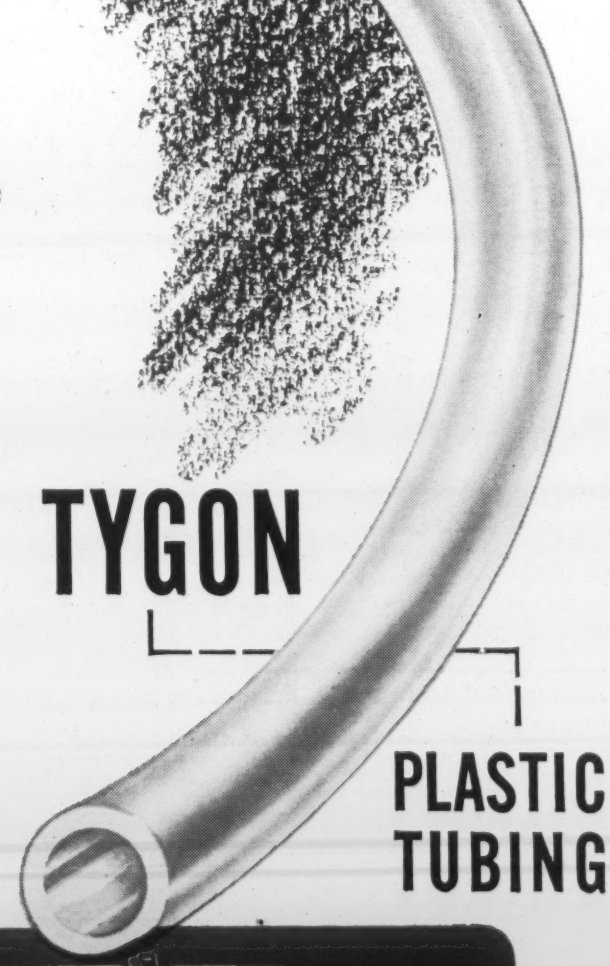
In the pages of this booklet are data every design engineer will want to have when faced with piping problems involving fluids or gases.

Where and how flexible plastic tubing can be used most effectively; how plastic tubings can differ even within a single family of resins; how to select the type and formulation to fit your requirements.

Specifically, of course, it deals with Tygon flexible-plastic Tubing — the flexible plastic tubing most widely used in laboratories, hospitals, food and beverage plants, and in the chemical industries.

Detailed tables outlining the physical, and chemical characteristics of the various standard Tygon formulations, complete table of chemicals to which the tubing is resistant, methods of assembly and cleaning, data on working pressures and temperatures . . . facts which simplify the problems of any engineer . . . are yours in this free booklet.

Write for it today. Ask for Bulletin T-97.



PLASTICS AND
SYNTHETICS DIVISION
420E

U. S. STONEWARE
AKRON 9, OHIO

For more information, turn to Reader Service Card, Circle No. 383

STOP...

Metal cleaning can be Automated, too!

Don't pyramid your production costs by using hand-operated metal cleaning methods. Detrex cleaning equipment can be built right into your automated line, thus eliminating slow and costly manual labor. In fact, Detrex has been building automated degreasers and washers for years.

Keep your metal cleaning processes in step with the rest of your production. Rely on Detrex quality and experience to maintain the pace. Mail the coupon for complete information on Detrex equipment or check your Sweet's Plant Engineering File.

☐ I am interested in automating my ___degreasing ___washing operation.

☐ Please send literature on standard Detrex equipment.

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CITY_____ ZONE_____ STATE_____

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DEGREASERS • DEGREASING SOLVENTS • WASHERS • ALKALI AND EMULSION CLEANERS • PHOSPHATE COATING PROCESSES

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PRICE$ AND SUPPLY

TIN PLATE ($/base box)

Hot Dip (1.25-1.50 lb)	9.70-9.95
Elec (0.25-0.75 lb)	8.40-9.15
Black Plate	7.50-7.60

METAL POWDERS ($/lb)[a]

Sponge Iron	.09-.10
Electrolytic Iron	
Annealed (99.5%)	.37
Unannealed (99+%)	.34
Stainless Steel	
302	1.05
316	1.40

[a]Price for −100 mesh.

NONFERROUS METALS

Mill base prices for large quantities; given in ¢/lb except where otherwise indicated

ALUMINUM

Pig (99-99.9%)	25-27
Ingot (99-99.9%)	27-29
Foil (5-0.5 mil)	55-77
Alloy Ingot (13, 43, A132, 214)	29-32
Sheet (1100, 3003; 3-.03 in.)[a]	40-45
Plate (1100, 3003, 5050, 3004, 5052)[a]	40-43

[a]Mill finish.

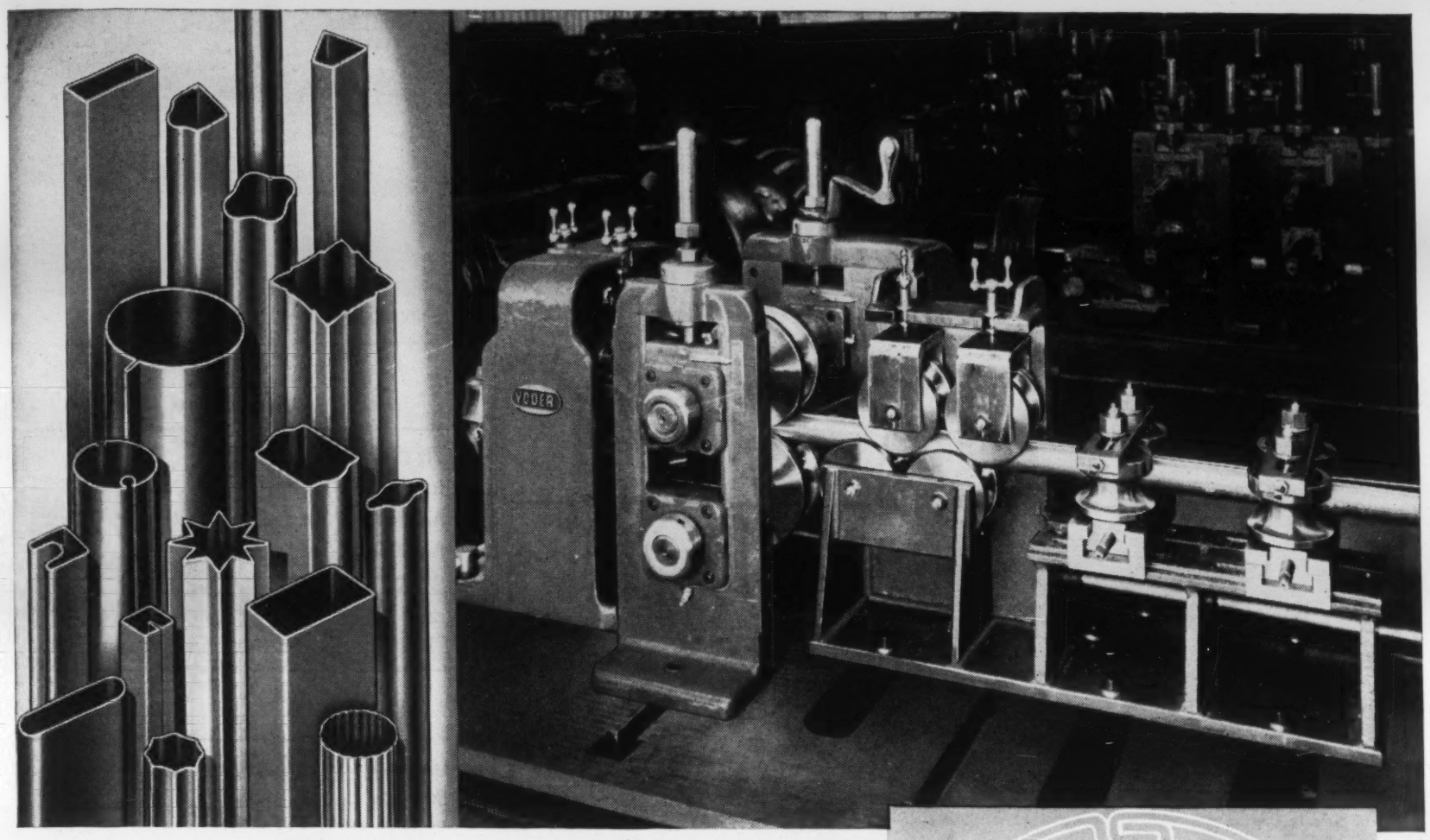
BRASS

Form	Cart., 70%	Low, 80%	Red, 85%
Sheet, Strip	50	53	55
Seamless Tubing	53	56	57
Rod (not f.c.)	50	53	55
Wire	51	54	55

COPPER

Ingot (elec)	36
Sheet, Strip (hot rolled)	58
Seamless Tubing	58
Rod, Drawn	55
Rod, Free Cutting	64
Wire	
Round	41
Square, Rectangular	45
Magnet	49

(Prices continued on p 192)



Lock-Seaming attachment at exit end of forming machine.

COLD ROLL FORMING TUBULAR SHAPES

Among the wide variety of things you can make on a Yoder Cold Roll Forming machine are round, square, oval, rectangular and other tubular shapes, such as illustrated at left above. The seams may be open, lapped, butted, dovetailed, interlocking, etc.—as indicated in Figures 1 to 6 at the right.

Millions of feet of such unwelded tubular shapes are made from coiled strip for conductor pipe, bedsteads, lamp stands, window channel, wiring raceways, carrying rods, etc. Production ranges from 20,000 to 50,000 feet per day, with only one operator and a helper.

Yoder offers you the cooperation of their engineering staff for designing and adapting their cold roll forming machines, auxiliaries, and tooling, for the low cost production of structurals, mouldings and trim, panels, tubular and other shapes, to meet individual needs.

The Yoder book on Cold Roll Forming is a complete, illustrated text on the art and the equipment needed for performing a variety of operations which can be combined with cold roll forming, at little or no extra labor cost. A copy is yours for the asking.

THE YODER COMPANY
5546 Walworth Avenue **Cleveland 2, Ohio**

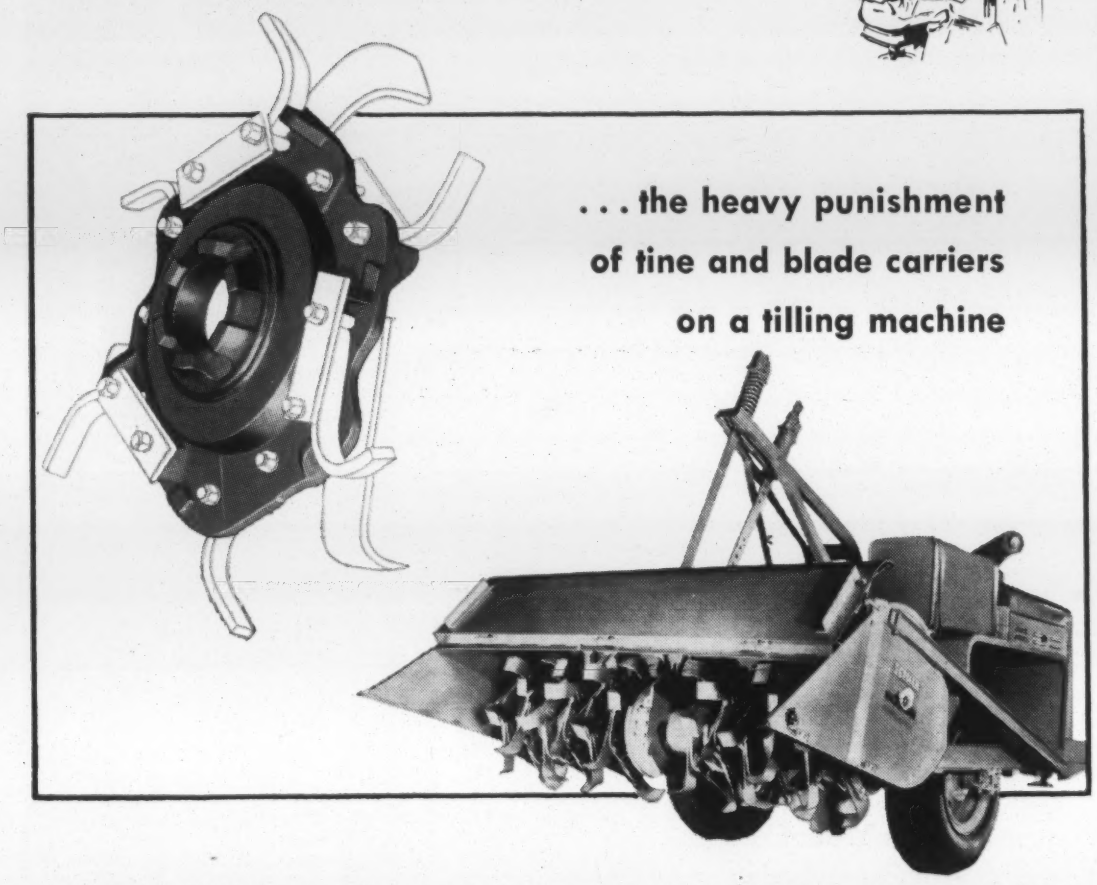
ENGINEERING YODER MANUFACTURING

COLD ROLL FORMING MACHINES
ROTARY SLITTING LINES
PIPE AND TUBE MILLS—Electric Weld

For more information, turn to Reader Service Card, Circle No. 448

How about Malleable?

It's the solution to many problems like this one



. . . the heavy punishment of tine and blade carriers on a tilling machine

The ability to take *tough going* has to be built into any soil working equipment. Malleable Iron plays an important part throughout the industry because toughness is its middle name!

In the Seaman Tiller shown above, over 1000 pounds of Malleable castings are used in each machine—in the carriers, transmission cases, torque tube brackets and other heavy-duty parts.

"Whether tilling heavy soil in California or stony fields in New England, our tillers with their tough malleable carriers stand up in service"—is the way Seaman Motors, Inc. of Milwaukee expresses it.

That describes the *end* result. Of equal interest to the *manufacturer* are the many processing and cost advantages that Malleable Iron has to offer. It will pay you to consult your nearest malleable foundry, or write to this Society for information.

Malleable FOUNDERS' SOCIETY

1800 Union Commerce Building Cleveland 14, Ohio

For more information, turn to Reader Service Card, Circle No. 480

PRICE$ AND SUPPLY

LEAD

Common Grade	16

MAGNESIUM

Pig (98.8%)	36
Ingot (98.8%)	37
AZ91B Ingot (die casting)	37
AZ91C Ingot (sand casting)	41[a]

[a]Delivered price.

NICKEL ($/lb)

Form	"F"	"A"	Monel
Ingot	.75[a]	—	—
Rod	—	1.07	.89
Sheet, C.R.	—	1.26	1.06
Strip, C.R.	—	1.24	1.08
Seamless Tube	—	1.57	1.29

[a]Delivered price.

TIN ($/lb)

Primary[a]	1.09

[a]Delivered price.

TITANIUM ($/lb)

Sponge (99.3+%)	2.50-2.75
Bars, Rod	7.10-7.35
Plate	9.25-11.25
Sheet, Strip	11.40-12.10
Wire	8.50-9 00

ZINC

Primary[a]	13-14[c]
Die Casting Alloys[b]	18-19[c]
Sheet	24
Ribbon	22

[a]Prime Western—Special High Grade.
[b]Alloys 2, 3, 5. [c]Delivered price.

METAL POWDERS ($/lb)

Aluminum[a,b]	.36
Brass[a]	.37-.47
Copper (el or red.)[a]	.50
Columbium	120
Molybdenum (98%)	3.80-4.10
Tantalum	49
Tungsten (C-red. 98.8%; H_2-red. 99+%)	4.20-5[c]
Zirconium	
Flash Grade	11.50
Electronics Grade	15

[a]Price for —100 mesh. [c]Delivered price.
[b]Freight allowed.

(Prices continued on p 195)

For more information, Circle No. 546 ➤

OTHER NONFERROUS METALS[a]

Cadmium (bars)	1.70
Gold	$35/troy oz
Indium (99.97+%)	$2.25/troy oz
Manganese (99.9%)	.33[b]
Palladium	$23-24/troy oz
Platinum	$103-105/troy oz
Silver	91¢/troy oz
Tantalum (sheet, rod)	55-60
Vanadium	3.45
Zirconium (sheet, strip, bar)	27-35

[a]Price in $/lb except where otherwise indicated.
[b]Delivered price.

What's Happening in Prices and Supply

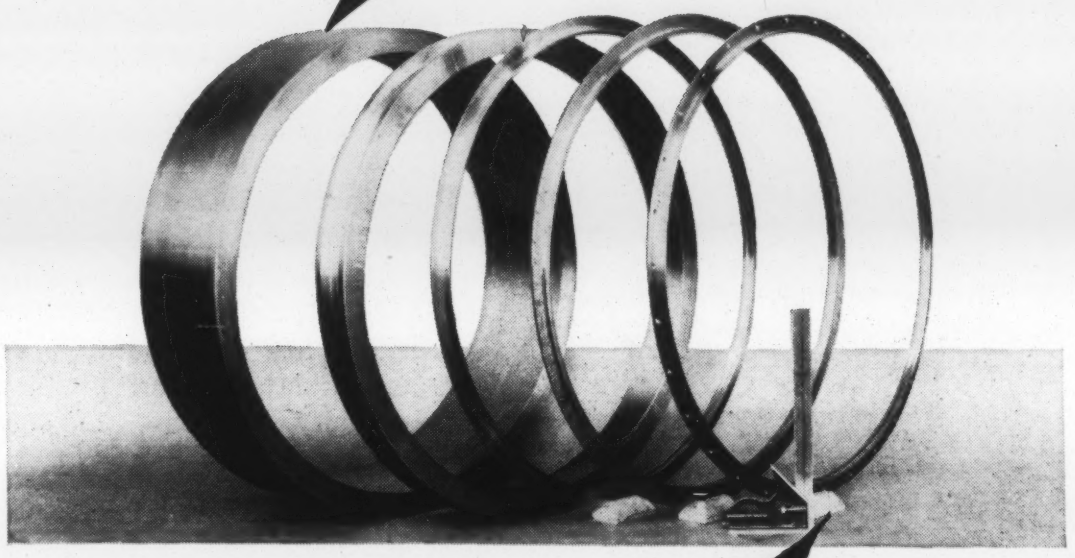
Steel—An all time high of 11 million tons was produced in October. Production ran at over 100% of capacity for many weeks in 1956 and in some areas expansion has been phenomenal. In the Eastern steelmaking district, for example, over 200 million tons of raw steel have been produced since the end of World War II. From 1946 to 1956 this district increased production by 53% compared to the national average of 40%.

On the other hand, steel plate shortages are expected for the next few years. According to Charles L. Huston, Jr., president of Lukens Steel Co., this will be due to the Government's $50 billion road building program and extensive expansion plans in the petroleum and construction industries. He also pointed out that if President Eisenhower's plan to produce 50 supertankers is realized, an additional need for 750,000 tons of heavy steel plate would be created.

Copper—Price fluctuations seem to be the order of the day. A 4¢ per lb reduction by both producers and smelters recently occurred as a result of overproduction. Soon afterward, demand increased and custom smelters raised the price 1¢ per lb. It seems likely that prices will continue to fluctuate

DURASPUN

CENTRIFUGALLY CAST by DURALOY



CUT and FINISHED by THE CUSTOMER

High Alloy rings for jet engines . . . we did the casting and rough finishing and the customer did the cutting and final finishing.

Centrifugally cast metal gives an exceptionally fine, dense, uniform grain structure. The strength of the metal approaches that imparted to a bar or ingot when it is hot forged. It produces an ideal metal for the tough service required of jet engine parts.

Incidentally, as evidence of our knowledge of and experience with tough alloy castings — static as well as centrifugal — the records show very few rejections by this engine manufacturer who subjected each of the many rings we furnished to his own very rigid tests.

May we suggest that you let Duraloy work on your high alloy castings — chrome iron, chrome nickel or nickel chrome? We have the experience and facilities for turning out high quality castings.

THE DURALOY COMPANY
OFFICE AND PLANT: Scottdale, Pa.
EASTERN OFFICE: 12 East 41st Street, New York 17, N. Y.
DETROIT OFFICE: 23906 Woodward Avenue, Pleasant Ridge, Mich.
CHICAGO OFFICE: 332 South Michigan Avenue

For more information, turn to Reader Service Card, Circle No. 489

Include K&J in your BRAINSTORMING

Every molding job at K & J goes through engineering — whether we start from scratch or follow customers' blueprints and specifications. Often we are able to suggest a change which means better performance, lower cost or other advantages. Make use of K & J's engineering facilities for your next job that calls for compression molding.

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Box 126, Stratford, Conn.
Phone Bridgeport 7-4293

For more information, Circle No. 505

PRICE$ AND SUPPLY

until the tension in the Middle East is resolved. In the meantime, expansion goes on. As a result of exploration drilling and tunneling, Anaconda recently announced an additional investment of $27,200,000 for further expansion of its new El Salvador Mine Project. The original estimate of 78,000,000 tons of ore averaging 1.6% copper has increased to 200,000,000 tons. Altogether, projected installations, combined with the nearby existing smelters at Potrerillos, are expected to provide an estimated annual production capacity of about 100,000 short tons of fine copper.

Tin—The base box price of most tin mill products has been advanced 10 cents and it is estimated that these prices will probably remain in effect until the end of April. The demand for electrolytic tin plate continues to remain considerably above the demand for hot dipped tin plate.

Lead—Both mine output and consumption of lead was higher in 1956 than in 1955. Production from domestic mines during the first nine months of 1956 increased to 260,000 tons from 254,000 during the equivalent period in 1955, according to the Bureau of Mines. Consumption of lead during the first eight months amounted to 782,495 tons, compared to 759,300 tons for the same period in 1955.

Magnesium—Production of primary magnesium ingot resumed capacity level after settlement of the August strike. And though the figure for the third quarter was below that of 1955, total tonnage through September was up 13% compared to last year. Wrought products were up 25% over 1955 at the end of the third quarter.

Tungsten—Reflecting a recent drop in the cost of tungsten ores, Electro Metallurgical Co. has cut all tungsten alloy prices by 30¢

MEEHANITE CASTINGS ARE MADE ONLY BY MEEHANITE FOUNDRIES

The American Laundry Machinery Co., Rochester, N. Y.
Atlas Foundry Co., Detroit, Mich.
Banner Iron Works, St. Louis, Mo.
Barnett Foundry & Machine Co., Irvington, N. J.
Blackmer Pump Co., Grand Rapids, Mich.
Centrifugally Cast Products Div., The Shenango Furnace Co., Dover, Ohio
Compton Foundry, Compton, Calif.
Continental Gin Co., Birmingham, Ala.
The Cooper-Bessemer Corp., Mt. Vernon, Ohio and Grove City, Pa.
Crawford & Doherty Foundry Co., Portland, Ore.
DeLaval Steam Turbine Co., Trenton, N. J.
Empire Pattern & Foundry Co., Tulsa, Okla.
Florence Pipe Foundry & Machine Co., Florence, N. J.
Fulton Foundry & Machines Co., Inc., Cleveland, Ohio
General Foundry & Mfg. Co., Flint, Mich.
Georgia Iron Works, Augusta, Ga.
Greenlee Foundry Co., Chicago, Ill.
The Hamilton Foundry & Machine Co., Hamilton, Ohio
Hardinge Company, Inc., New York, N. Y.
Hardinge Manufacturing Co., York, Pa.
Johnstone Foundries, Inc., Grove City, Pa.
Kanawha Manufacturing Co., Charleston, W. Va.
Kennedy Van Saun Mfg. & Eng. Corp., Danville, Pa.
Koehring Co., Milwaukee, Wis.
Lincoln Foundry Corp., Los Angeles, Calif.
Mattison Machine Works, Rockford, Ill.
Palmyra Foundry Co., Inc., Palmyra, N. J.
The Henry Perkins Co., Bridgewater, Mass.
Pohlman Foundry Co., Inc., Buffalo, N. Y.
The Prescott Co., Menominee, Michigan
Rosedale Foundry & Machine Co., Pittsburgh, Pa.
Ross-Meehan Foundries, Chattanooga, Tenn.
Sonith Industries, Inc., Indianapolis, Ind.
Standard Foundry Co., Worcester, Mass.
The Stearns-Roger Mfg. Co., Denver, Colo.
Valley Iron Works, Inc., St. Paul, Minn.
Vulcan Foundry Co., Oakland, Calif.
Washington Iron Works, Seattle, Wash.
Dorr-Oliver-Long, Ltd., Orillia, Ontario
Hartley Foundry Div., London Concrete Machinery Co., Ltd., Brantford, Ontario
Otis Elevator Co., Ltd., Hamilton, Ontario

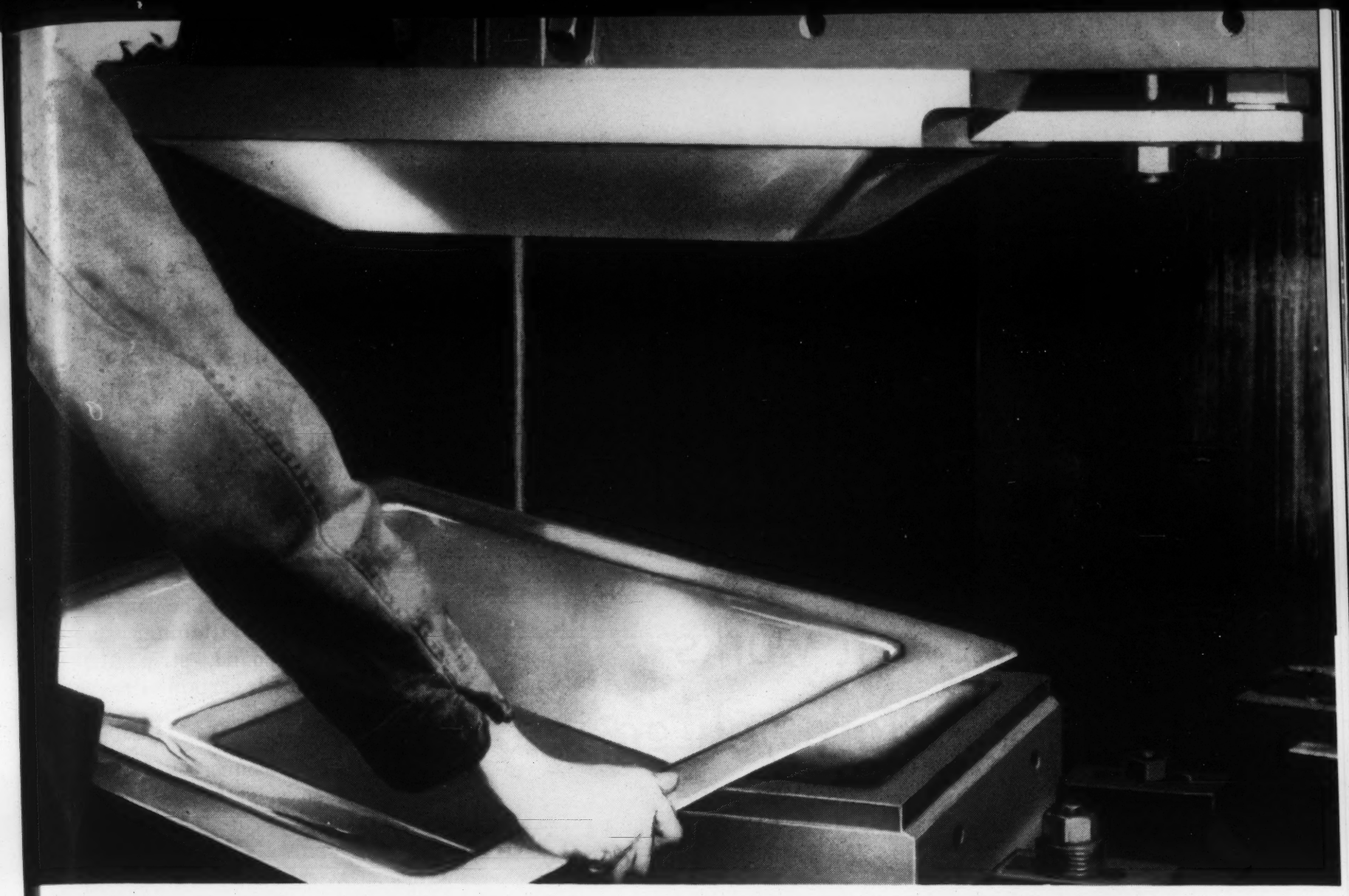
SEND FOR FREE BULLETIN 41 TODAY

Meehanite Metal as a Material for Forming & Stamping dies

Write today to Meehanite Metal Corporation, Department 1A, 714 North Avenue, New Rochelle, New York.

MEEHANITE®

For more information, Circle No. 501



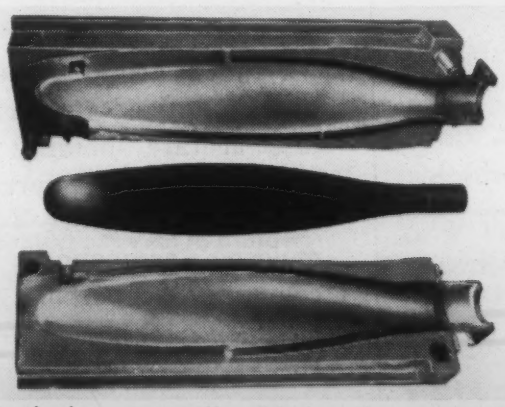
Increase die life and lower production costs with cast-to-form Meehanite metal dies

Longer service life is obtained with Meehanite dies because of their better wear resistance and freedom from galling, scuffing and scoring. Meehanite metal, combining the most desirable properties of gray iron and steel, is one of the most versatile die materials available.

Meehanite dies provide high strength and toughness combined with excellent self-lubricating properties. Dies made in Meehanite metal take on a permanent glass-smooth finish and assure long runs of flawless pressings and shapes. Meehanite dies are used successfully for deep drawing and shaping all steels and non-ferrous alloys.

Substantially lower production costs are achieved by casting large and complicated die parts in one piece rather than building up die assemblies. Machining allowances are held to a minimum and dies may be hardened by local or uniform heat treating without distortion.

For additional information, send for Bulletin No. 41 "Meehanite Metal as a Material for Forming & Stamping Dies."



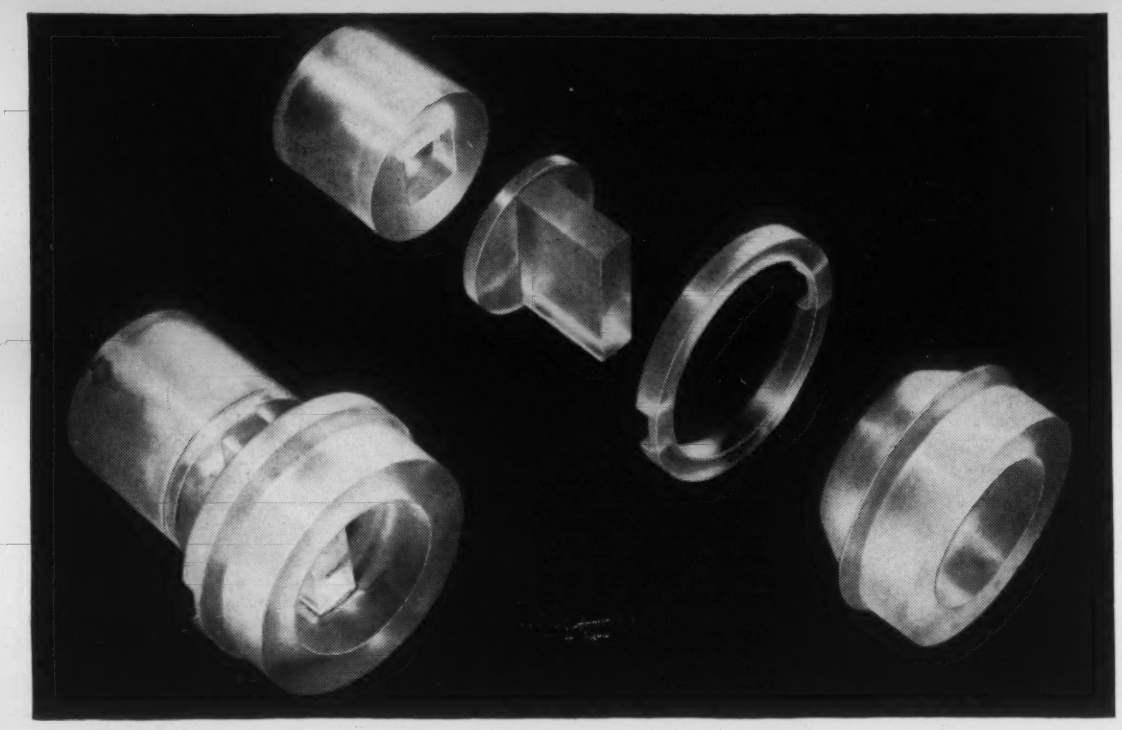
Steel airplane propeller blades that must be as near perfect as possible are manufactured with Meehanite dies that prevent distortion during quenching after heat treating. The dies shown contain cored passages through which cooling water flows.

Meehanite dies have been used in drawing and forming operations for over 25 years by the Ingersoll Products Division of Borg-Warner Corporation in the manufacture of stampings for the automotive, farm equipment and home appliance industries.

MEEHANITE BRIDGES THE GAP BETWEEN CAST IRON AND STEEL®

MEEHANITE METAL

MEEHANITE METAL CORPORATION, NEW ROCHELLE, NEW YORK



prove it works **before** you go into production

Machine that part from polystyrene and let us investment-cast it in the metal you plan to use. Test it and, if some change is indicated, repeat the process until you have the final answer. This cut-and-try method of proving a design and an alloy saves you a lot of time and money.

Polystyrene machines readily and is inexpensive. Complex patterns can be made in sections and assembled, then cast as a unit just as they'd be investment-cast in quantity. Thus parts for testing are exactly like you'll get in production, but they cost far less than cutting them out of metal.

Technical Data Available

When your idea is on paper, but before you start to make the polystyrene patterns, send us a blueprint. We'll figure the shrinkage factor for you, suggest possible gating arrangements and design modifications which may effect further economies.

The pamphlet, *A Guide for Making Polystyrene Patterns*, describes methods of machining and names sources from which this material can be obtained. For a free copy, write Precision Metalsmiths, Inc., 1077 East 200th Street, Cleveland 17, Ohio.

pour yourself an assembly with

PRECISION METALSMITHS INC.

INVESTMENT CASTINGS

For more information, turn to Reader Service Card, Circle No. 439

PRICE$ AND SUPPLY

per lb of contained tungsten. Tungsten alloys affected by the price change include ferro-tungsten ($3.15), tungsten metal powder ($4.20) and calcium tungstate nuggets ($2.85).

Titanium—Price reductions of 6-8% for titanium mill products were announced by Titanium Metals Corp. of America. This was the second cut made in 1956 and the fifth since 1954. The new price schedule shows titanium sheet down $1 a pound, strip $1.10, plate 75¢, and certain sizes of wire $2 a pound.

Polyethylene—Eastman Chemical Co. has announced a flat 10% discount on polyethylene, making the quantity price 36.9¢ per lb. Bakelite indicated that it will go along with Eastman's changes, and other polyethylene producers are expected to follow suit.

Polyethylene supply is expected to increase by at least 50% in less than a year. Many new plants will be producing the new high density (low pressure) polyethylenes. Long range estimates put polyethylene supply in the neighborhood of 1.2 billion pounds before 1960, which means that polyethylene will be the first billion pound plastic. Supply and demand are presently balanced; U.S. Tariff Commission figures for the first eight months of 1956 show total polyethylene sales at 329,247,435 lb and production for this period at 355,341,593 lb.

Cellulose acetate—Hercules Powder Co. raised the price of cellulose acetate molding powder 3¢ per lb. This increase brings the Hercules price for injection molding compounds of special colors to 39¢ per lb. Acetate film has been increased 3¢ per lb by Du Pont.

Polystyrene—Koppers Co. will build a full scale commercial plant for the production of expandable polystyrene beads. The new plant will be located at Koppers' Kobuta, Pa., operation, where the material has been produced since

If

PRODUCTION COSTS

of new designs

have you

stumped—

have you considered **versatile**

urethane foam?

New design advantages, faster production methods and lower fabrication costs are the reasons why urethane foam is being selected for modern fabricating techniques. Marked wear-and-tear strength, controllable density, good insulation properties (thermal, sound and electrical), and ability to bond during foam reaction to an almost unlimited number of materials, are among the profit-making characteristics of urethane foam.

If you manufacture or use anything which employs cushioning, padding or insulation in its design, get the full story on urethane foam today. Just write to **Mobay Chemical Company, Dept. MM-5, St. Louis 4, Mo.**

Mobay supplies basic chemicals for the manufacture of urethane foams which are already in use or under development for these applications:

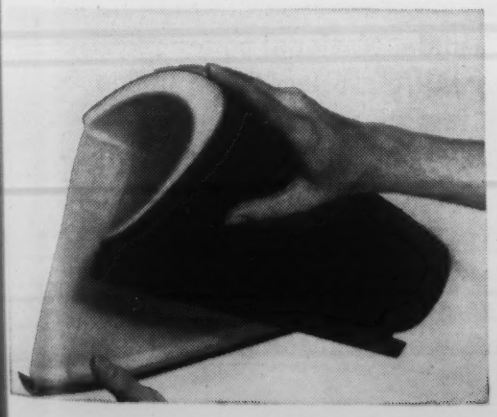
Auto safety padding
Furniture upholstery
Carpet underlay
Interlining for outerwear
Footwear
Household items.

An associate company of Monsanto

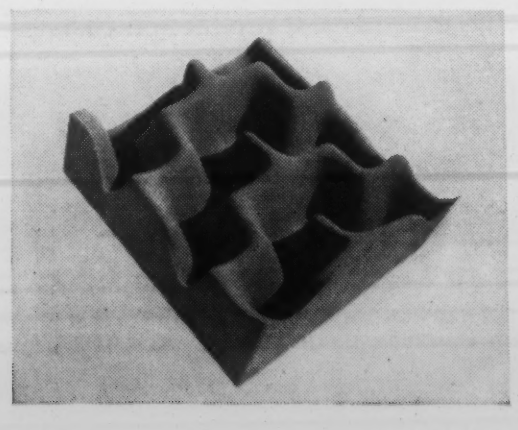
MOBAY®

First in Urethane Chemistry

Urethane foam can be molded in place; heat sealed, cemented or sewn to almost any type of material.

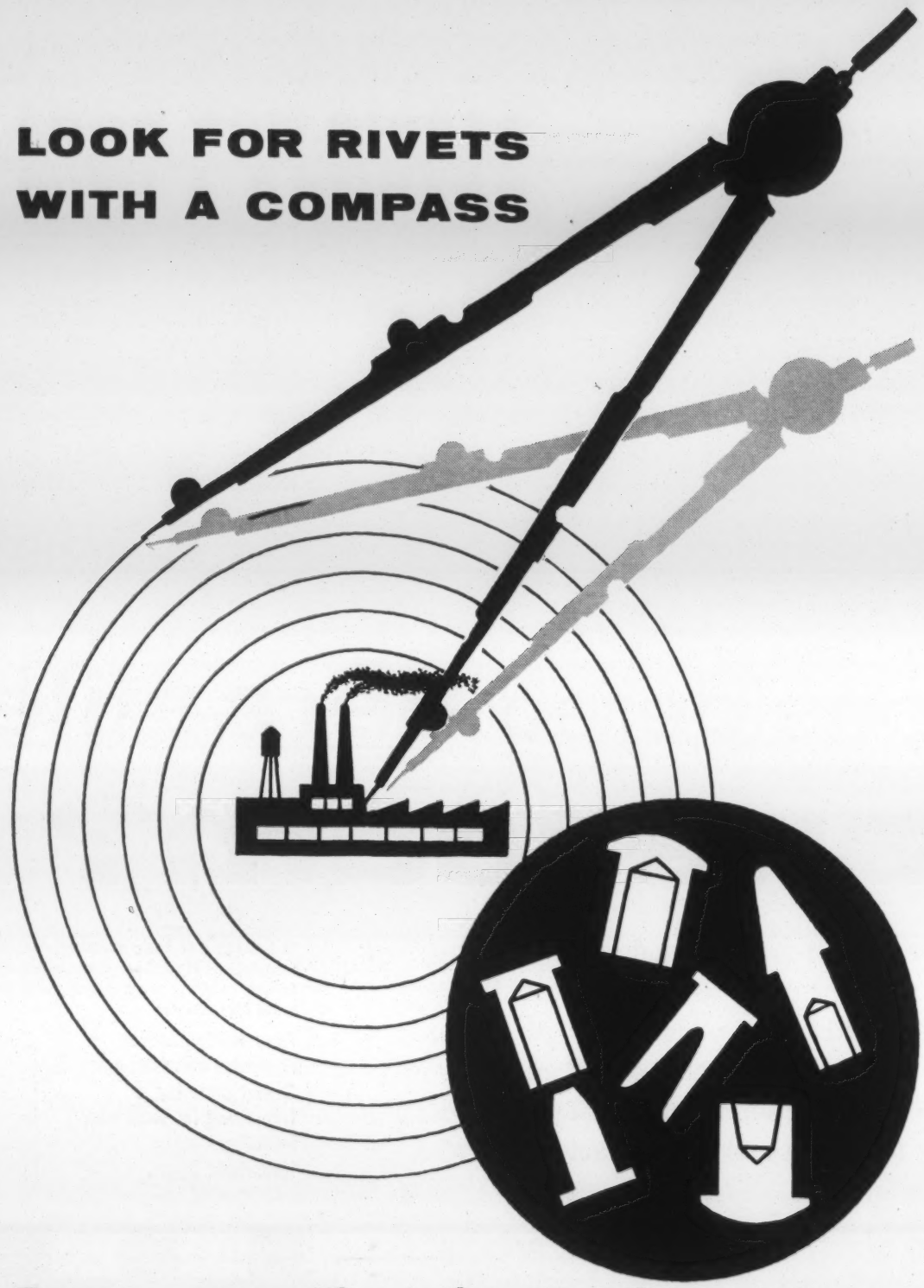


May be supplied pre-cut to a variety of intricate contoured shapes and patterns for special cushioning applications.



So tough you can hog-ring it right to seating springs; roll and crimp it to suit your fancy; tack or staple it in place.

For more information, turn to Reader Service Card, Circle No. 540



Draw a 300-mile circle around your plant —

You're almost certain to circle one of Milford's five manufacturing plants!

There's hardly a metalworking plant in the country that isn't within overnight trucking distance of one of Milford's five manufacturing plants. And 20 sales offices add to the convenience of ordering and *getting* rivets when you need them NOW!

To improve product appearance and strength
. . . to take full advantage of automatic assembly
. . . to cut delivery time and production costs
—get in touch with Milford first!

THE MILFORD RIVET & MACHINE CO.
MILFORD, CONNECTICUT • HATBORO, PENNSYLVANIA
ELYRIA, OHIO • AURORA, ILLINOIS • NORWALK, CALIF.

For more information, turn to Reader Service Card, Circle No. 413

Koppers first announced its availability in 1953. According to B. J. C. van der Hoeven, vice president, Koppers expects to be the first in the country to produce the beads in commercial quantities.

Vinyls—U.S. Rubber Co. announced a price increase averaging 4% on its vinyl-coated Naugahyde upholstery fabrics.

Defense Secretary Urges Nickel Saving

Although nearly 80 million pounds of nickel were diverted from the national stockpile to ease the shortage in 1956, and no nickel at all will be stockpiled during the first quarter of 1957, a serious shortage still exists.

In a recent statement, Charles Wilson, Secretary of Defense, urged industry to further reduce its consumption of this vital metal. "Many segments of industry are learning to do without nickel, to make better use of nickel scrap, and to use alloys containing less of this valuable metal," he said. He pointed out that the steel industry has made strong efforts in this direction by shifting to the 200 stainless series.

"If energetically pressed," he said, "this one substitution would reduce by as much as 10% the national consumption of nickel."

Mr. Wilson emphasized that "all three military departments have told designers to seek out ways to replace high-nickel stainless steels in their equipment with the new manganese-type alloys, or with nickel-free stainless steels, aluminum, plastics or other non-nickel materials. National policy requires that military needs for nickel be met in full.

"However," he said, "fullest use of the substitute materials throughout all industry would also enable stockpiling to proceed and leave a more abundant remainder for civilian consumption."

More complete corrosion of anodes by using the HARSHAW ANOCAP

The Harshaw Anocap is a rubber electrode assembly protector. Easily slipped over the anode hook and down over the anode top, the Anocap enables you to corrode an additional 2 to 4 pounds of metal from each anode.

Many more time and money-saving benefits are yours in the inexpensive Harshaw Anocap:

1. More usable metal—less recasting or scrap loss.
2. Shorter stub—easily placed directly into anode saver basket and consumed.
3. Anode hook protected, thus giving it longer life.
4. With Anocap in place on hook, anode can easily be screwed on or removed from hook.
5. Anocap pays for itself during first use.
6. Entire anode can be below solution level. Shorter anodes can be used and thus a larger quantity of anodes can be obtained from any given poundage of anode metal.
7. When using Anocaps, solution level of bath is not critical.
8. Anocaps can be used with any standard oval anode.

You'll make new savings on anodes tomorrow if you order Harshaw Anocaps today. Send or call in your order to the nearest Harshaw sales office.

HARSHAW

THE HARSHAW CHEMICAL COMPANY

1945 East 97th Street • Cleveland 6, Ohio

Chicago 32, Ill. • Cincinnati 13, Ohio • Cleveland 6, Ohio • Houston 11, Texas • Los Angeles 22, Calif.
Detroit 28, Mich. • Philadelphia 48, Penna. • Pittsburgh 22, Penna. • Hastings-On-Hudson 6, N. Y.

For more information, turn to Reader Service Card, Circle No. 377

With parts like these...

It's sure costing you money if you don't barrel finish

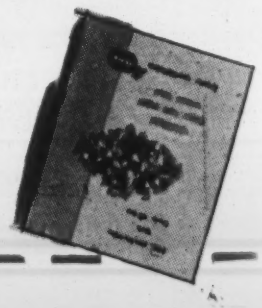
You would be surprised at the various *shapes* and *sizes* of parts being deburred, descaled, or burnished in a barrel today. You would be even more surprised at the big savings in time and work.

So why not find out whether the parts *you* produce lend themselves to tumbling? With technical data available to show you how to make an easy change to tumbling, it's costing you money to continue finishing by manual methods.

OAKITE COOPERATES

One good source of information for you is your experienced Oakite man. He'll survey your needs on *precleaning* . . . recommend efficient cleaning materials for the job. From the complete line of Oakite barrel finishing compounds, he can supply you with one to match your abrasive or burnishing media. He can advise proper barrel speed, ratio of media-to-work for various steel, brass, aluminum, zinc or alloy parts. He'll tell you when to use an alkaline material, when to use an acidic one. He'll pilot-finish samples in the Oakite laboratories.

In short, if you're going to tumble your work . . . *and you should* if at all feasible . . . your Oakite Technical Service Representative will prove to be a good man to know. Send for Bulletin F-9339. Oakite Products, Inc., 18 Rector Street, New York 6, N. Y.



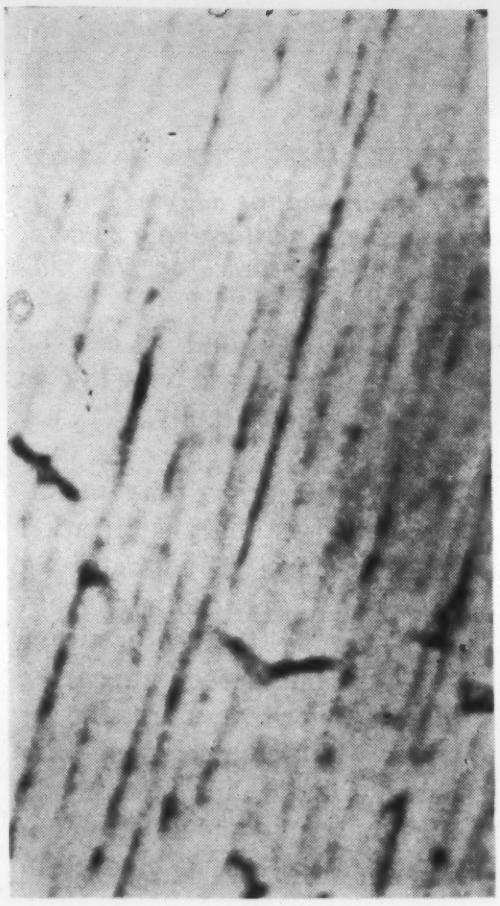
SPECIALIZED INDUSTRIAL CLEANING
OAKITE®
MATERIALS · METHODS · SERVICE
SCIENCE

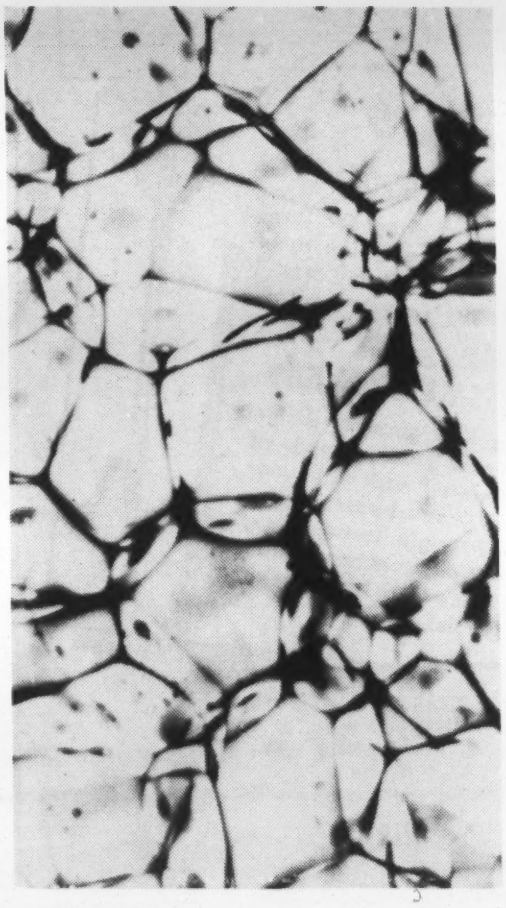
Barrel-finishing already?

The Oakite man is still a good man to know for his experience, unbiased help, and the sample-testing service and complete line of compounds he makes available.

Export Division Cable Address: Oakite
Technical Service Representatives in Principal Cities of U. S. and Canada

For more information, turn to Reader Service Card, Circle No. 495





Difference *between x-ray and ordinary light microscopes is demonstrated here. In examining aluminum-tin alloy, ordinary microscope (left) shows only a few tin lines and surface scratches. X-ray microscope (right) reveals complete grain outline.*

Structure *of leaded steel, ordinarily difficult to see, is easily revealed by new microscope.*

X-Ray Microscope Penetrates Interior

■ A new microscope recently developed by General Electric Co. promises to reveal many hitherto hidden facts concerning characteristics and properties of metals, rubber and other materials.

The result of four years of development work, the new x-ray microscope magnifies up to 1500 times, discloses inner structures and permits three-dimensional examination of the specimen. It is expected to be extremely useful in uncovering and explaining factors concerning corrosion in metals, the effect of foreign materials in metals, the soundness of electroplated coatings and the effects of various processes on the behavior and structure of metals.

Secret of the x-ray microscope lies in the extremely small size of the focal spot, which emits x-rays when bombarded with electrons. This target is only 0.000040 in. in dia and x-rays emanating from such a small spot fan out in all directions, thus magnifying any object through which they pass. Although not as powerful as the electron microscope, the new instrument has the advantage of penetrating to the interior of the object and revealing structures otherwise not visible. In addition, no special preparation of speci-

CASE HISTORY 1

REQUIRED:

A dependable supply of this small, machined electrode to meet customer's quality and quantity needs at reduced cost.

HASSALL SOLUTION:

Hassall-designed re-heading process, involving no critical dimension changes, resulted in a 59% cost reduction to customer.

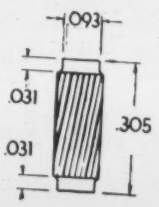
CASE HISTORY 36

REQUIRED:

Less costly manufacturing method for this small stainless steel fluted pin which cost $19.20 per M as a screw machine product.

HASSALL SOLUTION:

Cold forming by Hassall at a cost of $2.95 per M gave the customer an 85% cost reduction on this part.



SPECIALTY MANUFACTURER OFFERS SAVINGS ON SMALL PARTS AND FASTENERS

Multiply these case histories a thousandfold and you'll get some idea of the variety of tough problems we crack, and the savings we effect for our customers in the course of a year.

Our cold-heading process—supplemented by secondary operations—imposes amazingly few limitations on the parts and fasteners we can make. Don't forget that we are not limited to "stock" sizes. These illustrations show that Hassall—a specialty supplier — can show you substantial savings, better deliveries and technical assistance on your small parts and fasteners.

Proof? Send us your specifications or write for catalog.

John Hassall, Inc., P. O. Box 2174 Westbury, Long Island, New York.

CASE HISTORY 89

REQUIRED:

Customer looking for low cost, high production rate method of producing mandrels for rotary dental brushes.

HASSALL SOLUTION:

Hassall-originated design for cold-heading replaced chamfered end with tumbled, round end; maintained rigid specifications for straightness and made low-cost production possible.

CASE HISTORY 37

REQUIRED:

Bumper bolt with bonded rubber cap for license plate support.

HASSALL SOLUTION:

The large head on this bolt would ordinarily call for screw machining but the two lugs under the head ruled this out. Progressive cold-heading was Hassall's answer.

HASSALL

SINCE 1850

NAILS, RIVETS, SCREWS AND OTHER COLD-HEADED FASTENERS AND SPECIALTIES

For more information, turn to Reader Service Card, Circle No. 429

News OF INDUSTRY

X-ray microscope, *adapted for direct viewing. By attaching a camera, images can be recorded on film.*

men is required and it can be used for either direct viewing or for camera photography.

One of the major benefits it is expected to bring to the metalworking field is the visualization of minute foreign particles in metals which are ordinarily invisible because they are either beneath the surface or appear to be identical with the surrounding metal. X-ray microscopy is also expected to aid in identifying plastics materials and in studying such things as the deterioration of fibers and textiles, the depth to which dyes and adhesives penetrate, surface changes due to weathering and the distribution of particles in a mixture or suspension. In the rubber industry, it may be useful in controlling the quality of carbon black.

Vacuum Symposium Held in Chicago

Forty-two technical papers covering fundamental developments in vacuum technology were presented at the third national symposium on vacuum technology held in Chicago recently. Metallurgical and chemical applications, instrumentation and control of high vacuum equipment, vacuum distillation and evaporation, methods

TUBEMANSHIP CENTER OF THE LIGHTWEIGHT METALS BUSINESS

There used to be a time—remember—when all a company had to do to meet the demands of its customers was produce one type of its particular product.

It isn't that way any more. Take aluminum tube for example. To supply the aluminum demands of its customers, Wolverine maintains facilities for the production of both drawn and extruded tube. Each of these types is available in many sizes; in different alloys; in finned or prime surface form; in straight lengths, and in standard, medium and extra long coils.

And that isn't all by a long shot. Customers—requiring tubular shaped parts of aluminum—find that Wolverine has the facilities and the "know-how" for that type of production. Wolverine's fabrication facilities include spinning, finning, bending, coiling, flaring, beading, etc. —to name but a few. Aluminum services also include the production of rigidly quality controlled extruded aluminum shapes.

Anticipating customer demands and having the plants, equipment, experience and skilled employees needed to meet them is what Wolverine means when it refers to Tubemanship. Next time you need aluminum tube, tubular shaped parts or extruded shapes ask for a Wolverine quote before placing your order—make sure of products built the Wolverine Tubemanship way. Write, too, for Wolverine's General Products Catalog.

CALUMET & HECLA, INC.
CALUMET DIVISION
WOLVERINE TUBE DIVISION
FOREST INDUSTRIES DIVISION
GOODMAN LUMBER COMPANY
CALUMET & HECLA OF CANADA LIMITED
CANADA VULCANIZER AND EQUIPMENT COMPANY LIMITED

WOLVERINE TUBE

Division of Calumet & Hecla, Inc.

1439 CENTRAL AVENUE, DETROIT 9, MICHIGAN

Manufacturers of Quality-Controlled Tubing and Extruded Aluminum Shapes

PLANTS IN DETROIT, MICHIGAN, AND DECATUR, ALABAMA. SALES OFFICES IN PRINCIPAL CITIES

EXPORT DEPT., 13 EAST 40TH STREET, NEW YORK 16, N. Y.

5705

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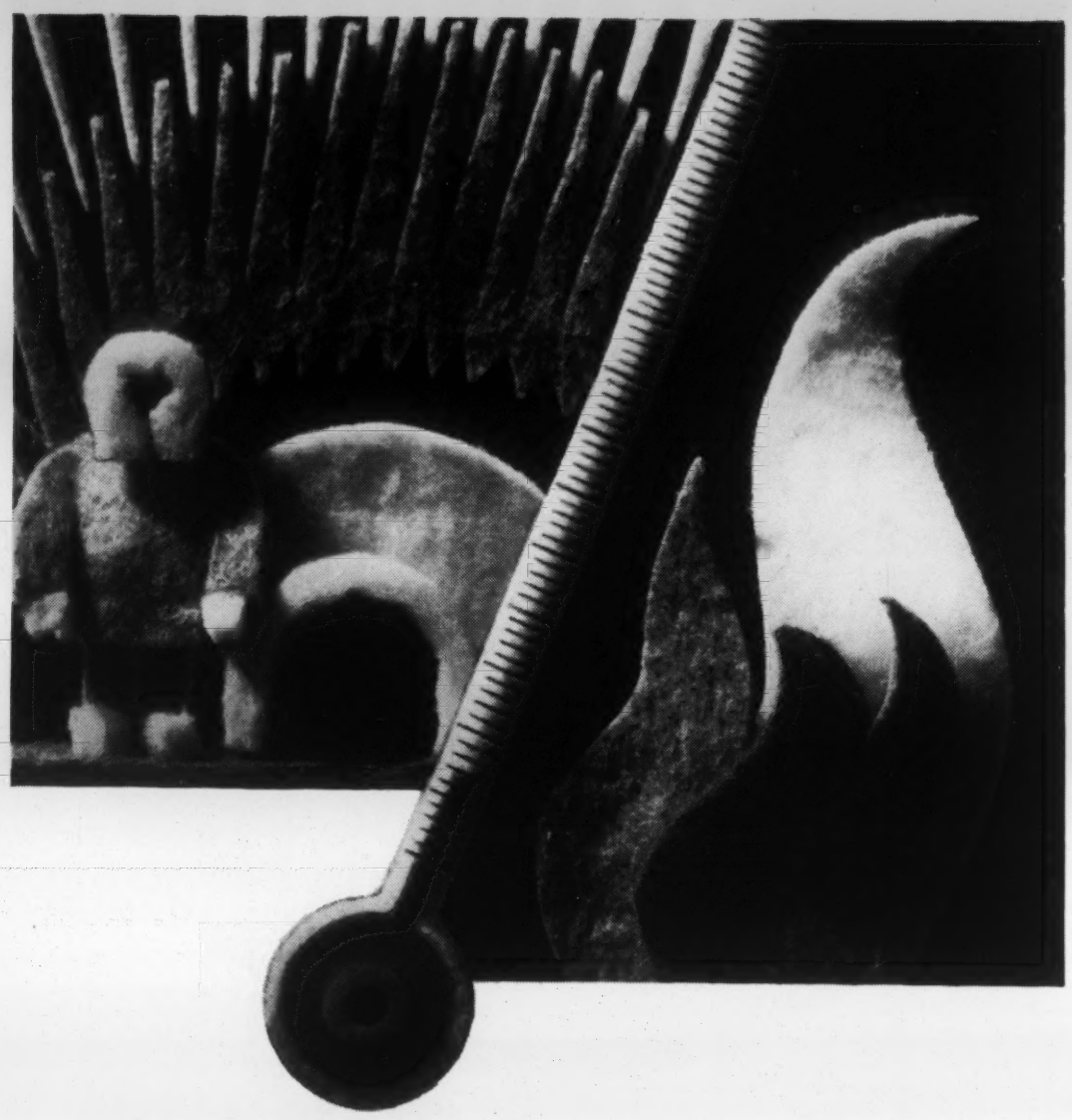
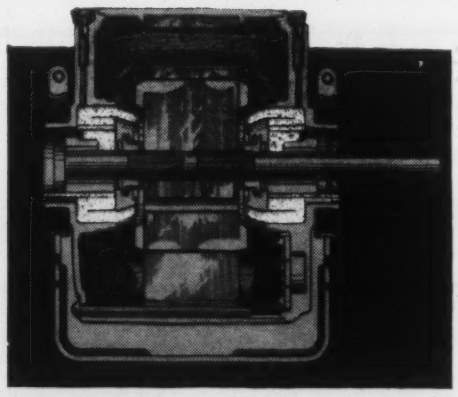


Felt Stands the Gaff

...FROM −80°F TO 250°F



FELT IN USE . . . Small motors use felt washers, rectangles, odd shapes and wicks in many places to increase reliability, like on this Redmond Micromotor shown here. Felt wicking and pourous bronze bushings provide positive lubrication for long, heavy-duty operation in any position. Felt seals also keep dirt and dust out of vital areas.

Felt by Felters has what it takes when operating conditions are extreme.

Stands over 30 days at 250°F of dry heat without materially weakening its structure. Same at −60°F as at normal 74°F and at −80°F its properties are only slightly different. Even when exposed to greater extremes, felt will always resume its natural feel.

Send for Design Book

Complete technical data has been prepared for your use in selecting and specifying the *right* felt for the job your product has to do. Send for it today. The Felters Company, 220 South St., Boston 11, Mass.

Get the Best, Specify

FELT by FELTERS

Manufacturers of Felt and Felt Products *Representatives in All Principal Cities*

For more information, turn to Reader Service Card, Circle No. 484

News OF INDUSTRY

and techniques for obtaining high vacuum, and vacuum technology as related to atomic energy and extraterrestrial problems were among the many topics discussed. Sponsored by the Committee on Vacuum Technology, the meeting attracted more than 500 representatives from industry, government and universities.

Three Color Films Cover Materials

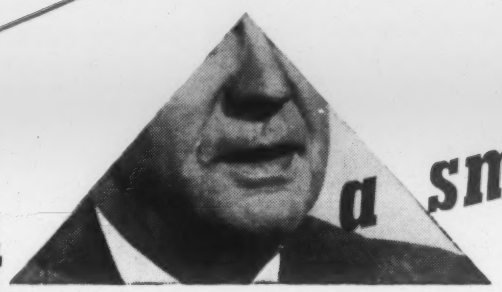
Three new color films on materials have been released. "The Petrified River—The Story of Titanium," begins with prospecting for the ore and ends with peaceful uses of atomic energy. Requests go to: Graphic Services Section, U.S. Bureau of Mines Experiment Station, 4800 Forbes St., Pittsburgh 13, Pa.

"The Science of Making Brass," which recently won a first prize for technical films, explains the step-by-step process of making brass and other copper alloys in the form of sheet, wire, rod and tube with some remarkable close-ups of casting, extruding, piercing, drawing and rolling operations. Write: Modern Talking Picture Service, Inc., 3 East 54th St., New York 22, N.Y.

"Quality Unlimited" describes the manufacture of wire rope, including chemical and physical tests. It is available from Colorado Fuel and Iron Corp., 575 Madison Ave., New York 22, N.Y.

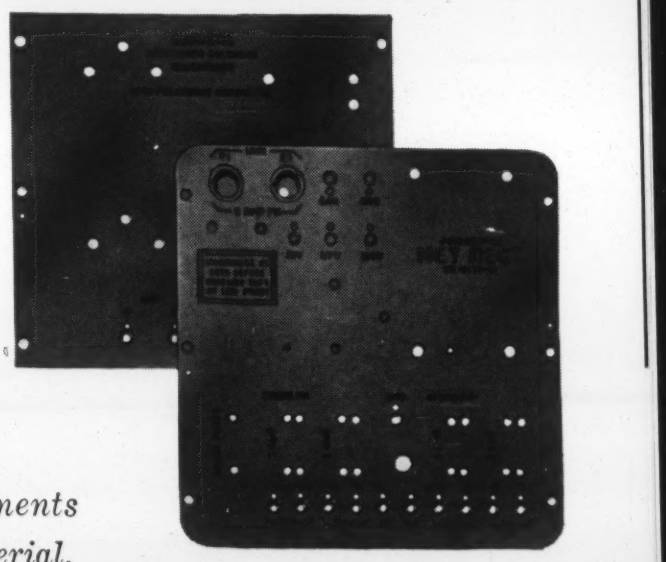
Plastics Engineers to Meet This Month

"Fifteen Years of Plastics Progress" is the theme around which the 13th annual technical conference of the Society of Plastics Engineers is being conducted. The conference will be held in St. Louis this month, Jan. 16-18. New materials, processes, technical de-

talk about  a smooth molding job!

1 surface smooth within 20 thousandths inch for over 10 inches

A smooth surface is just one out of 4 basic requirements we meet in molding the mounting plate and panel for WESTERN ELECTRIC, shown below. These parts were previously machined from a laminated sheet... now SHAW compression molds them from high impact phenolic with unusual results. Here are 3 more benefits for our customer –



2 close dimensional tolerances held for 72 holes over 64 square inches

3 panels free from flash on all cut-off surfaces on all holes

4 characters engraved in the mold to protrude nearly 1/32-inch

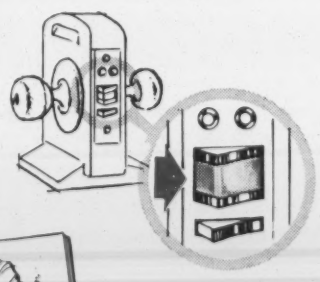
... all unusual accomplishments in molding impact material.

molded by **SHAW**

the new SCHICK "25"
transfer molded
of melamine
for SCHICK INC.

the SUPER CHAMP
HAND TOOL
hand grips
injection molded
of butyrate
for AIRCRAFT-MARINE
PRODUCTS, INC.

SARGENT lock assembly
latch bolt insert
injection molded
of nylon
for SARGENT
and COMPANY



OUR 64 YEARS EXPERIENCE COSTS YOU NOTHING EXTRA

But, you gain because we help you design excess costs out of your part or product. Our own automation equipment speeds up production, is tailored to your needs to give you the finish you want... and to meet your delivery date. Consult us freely on your custom plastic molding needs. Ask to see what we have done for others. No obligation. SHAW INSULATOR COMPANY, 146 Coit Street, Irvington, New Jersey.

WRITE *for our new facilities brochure:*
"SHAW TAKES THE PROBLEMS OUT OF PLASTIC MOLDING"

SHAW
since 1892

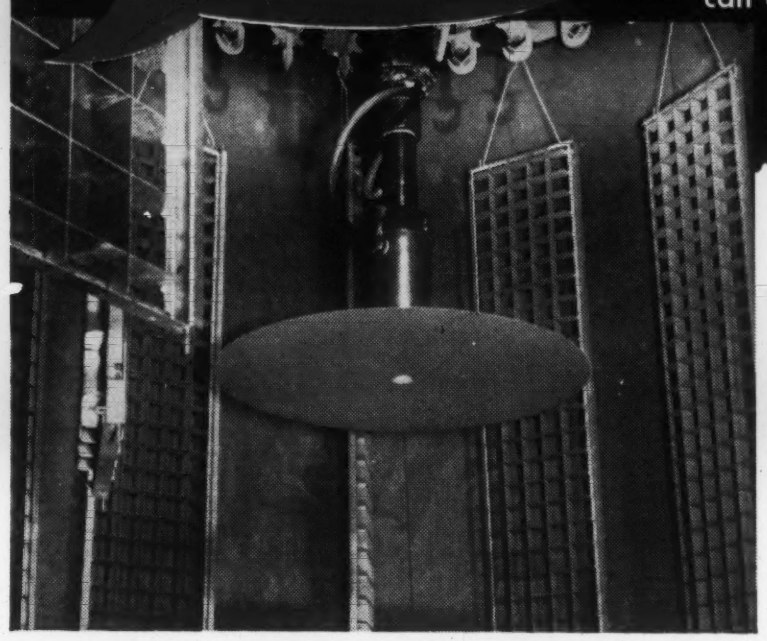
SHAW *custom molds all plastics*
TRANSFER • COMPRESSION • INJECTION

For more information, turn to Reader Service Card, Circle No. 471

What d'ya mean . . .

You're too little to use RANSBURG Electrostatic Spray Painting?

If your production justifies conveyorized painting, chances are RANSBURG NO. 2 PROCESS can do YOUR painting job better . . . at less cost.



RANSBURG NO. 2 PROCESS *accounts for a 50% savings in paint costs in finishing fluorescent lighting fixture parts for* MELROSE LIGHTING COMPANY, *Philadelphia. Melrose is a small plant employing only 25 people.*

Not only big industrial manufacturers like G. E. . . . Whirlpool-Seeger . . . Westinghouse and Republic Steel, but little plants, too, are using RANSBURG NO. 2 PROCESS in their finishing departments to help keep mounting manufacturing costs in line.

A typical example is Melrose Lighting Company, Philadelphia. They make industrial fluorescent lighting fixtures and employ only 25 people.

Formerly, according to F. Homer Hagaman, owner Melrose Lighting, when their fixture louvres were hand sprayed, they painted only 70 pieces per hour. Now, with Ransburg Electro-Spray, he reports they get over 200 per hour.

Production on the fixture end parts jumped from 400 pieces per hour by hand spray to over 2000 an hour electrostatically—a 400% increase!

Along with improving quality of the work, stepping up production, and cutting labor costs, Melrose is enjoying a 50% paint savings.

Let us show you how Ransburg No. 2 Process can lower YOUR painting costs. Write for our new No. 2 Process brochure on electrostatic spray painting. Numerous production-line examples show how other manufacturers are cutting finishing costs . . . increasing production . . . and improving the uniformity and quality of their work with Ransburg equipment.

Ransburg ELECTRO-COATING CORP.
Indianapolis 7, Indiana

RANSBURG

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velopments and applications will be discussed by engineers and scientists from all phases of the plastics industry.

Among the many topics covered will be the use of alkyd molding compounds in electrical and electronic applications; the use of flexible plastics sheets for control of radioactive contamination; the effect of radiation on the permeability of polyethylene; properties and applications of polystyrene foams; fundamentals of sandwich construction; design of rigid thermoplastic piping; and the use of synthetic fibers in formable acrylic sheet. Several papers on the new high density polyethylenes will be of particular interest. These will cover such things as mold shrinkage and dimensional stability; its use as a melt spun fiber; and general gating and molding data.

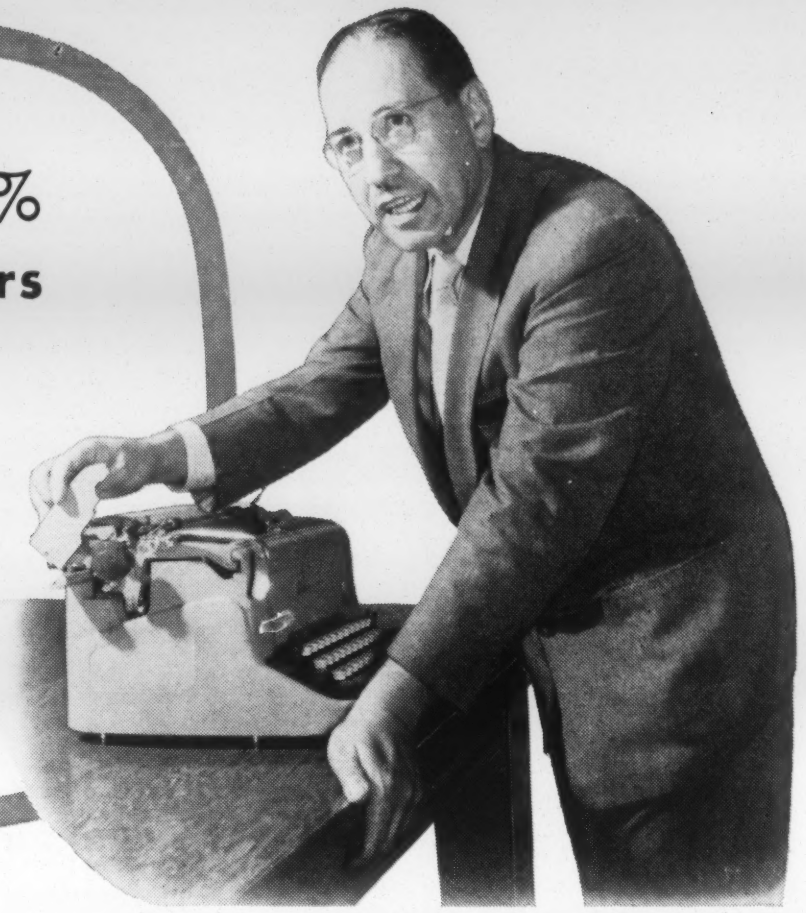
Tin Plate Variations Standardized by AISI

A standard on coating weight variations for two new classes of tin plate was announced by the 13 tin plate manufacturers of the United States and Canada who met at the Birmingham Regional Technical Meeting of American Iron and Steel Institute in October.

According to Douglas H. W. Allen, metallurgical statistical analyst for the American Iron and Steel Institute, the new standards were developed because no previous information on standard coating variations had been published on the two new classes of tin plate. The two new types of tin plate have very light coatings of tin. In the event of national emergency, it is anticipated their use will increase as a conservation measure.

"The main survey," Mr. Allen said, "was designed, as a matter of pure practicality, to provide an

"We cut our costs 99.1% by deburring end covers with ALMCO BARREL FINISHING EQUIPMENT"



J. P. Scavo of the Underwood engineering department shows typewriter parts deburred with Almco equipment.

UNDERWOOD CORPORATION PROCESSES 1600 TYPEWRITER PARTS IN ONE HOUR, SAVES $6632 PER YEAR

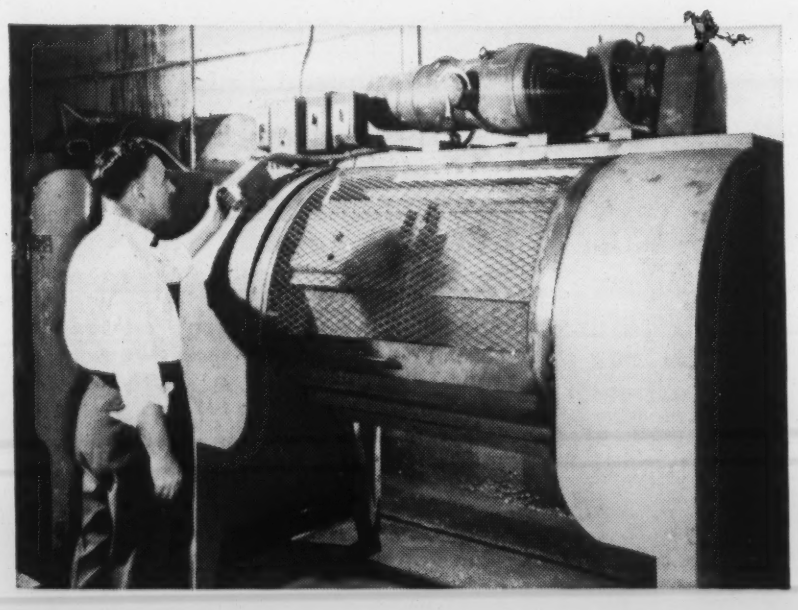
Substantial savings every day with Almco barrel finishing equipment! That's been proven at the award-winning Underwood Corporation, Hartford, Connecticut. An Almco Model DB-400 speedily deburrs typewriter end covers — and the clean, uniform surface provides an ideal base for paint adhesion.

Previously, Underwood used wheel deburring methods . . . 150 parts were processed each hour . . . rejects were frequent . . . labor costs were high.

Now, it takes only one hour to process 1600 parts. Rejects have been eliminated. And, with Almco equipment, Underwood saves $6632 a year on end covers!

Controlled barrel finishing by Almco provides a wide range of applications. Metal parts can be deburred . . . polished . . . burnished . . . ground . . . descaled . . . degreased. Surface porosity can be reduced — radii can be formed to rigid specifications and low microinch surfaces can be obtained economically. Large parts, too, can be precision-processed with Almco Supersheen equipment and materials.

It's simple to get expert advice on barrel finishing from Almco. Write on company letterhead asking for an Almco engineer to call. Or send in your sample parts with specifications on results desired. Expert Almco technicians will provide a factual report with no obligation.



A flip of the switch and hundreds of Underwood typewriter parts are quickly and precisely deburred in the Almco Model DB-400 barrel finishing machine.

SEND FOR YOUR ALMCO BARREL FINISHING HANDBOOK

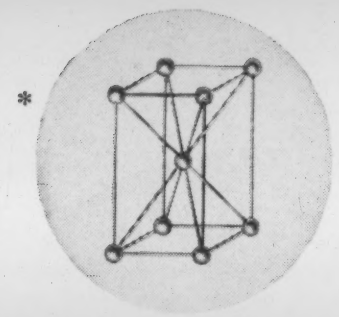
52 fact-filled pages of barrel finishing information! More than a catalog, it shows how to adapt the Almco Supersheen process to many types of metal parts. Send for your copy today.

ALMCO SUPERSHEEN METHOD FOR *SPEED FINISHING*

Division of Queen Stove Works, Inc.
31 Marshall St. • Albert Lea, Minn.

Sales Engineering Offices in Chicago, Detroit, Los Angeles, Newark, New Haven, Philadelphia and London, England.

For more information, turn to Reader Service Card, Circle No. 487



Somers THIN STRIP

*PURE TIN plated on Somers Thin Strip.

Somers engineers have developed a special hot tin plate process which now will provide the smooth surface, solderability, adherence and complete absence of slag so essential to manufacturers of:

PRINTED CIRCUITS

CAPACITORS

CABLE WRAPPING

Tin coatings of .00002 to .00008 and .0002 to .0003 are available on brass, copper, bronze and other Thin Strip metals in gauges from .012 down to .002, widths from ⅛" to 6" and wider.

And, of course, Somers exacting standards for tolerance, tensile strength and other physical properties are rigidly maintained.

Whatever your requirements for tin plated thin strip, you can depend on Somers long experience and modern equipment for a quality product.

Write for further information and confidential data blank. Somers will gladly analyze your problem without obligation.

FOR EXACTING STANDARDS ONLY

Somers

Somers Brass Company, Inc.
108 BALDWIN AVE., WATERBURY, CONN.

For more information, Circle No. 418

News OF INDUSTRY

over-all measure of the industry practice in the long run. The results were expected to reflect the coating weight levels which the buyer of relatively large items—say 50 or more packages to the shipment — should expect." An auxiliary survey was conducted to reflect the variations to be expected by the small buyer.

Some New Materials Needed for Defense

The National Inventors Council periodically lists problems to which the military establishment is seeking solutions in the hope of enlisting and channeling inventive thinking along lines that will benefit the defense effort. The present list supplements the listing issued in 1954.

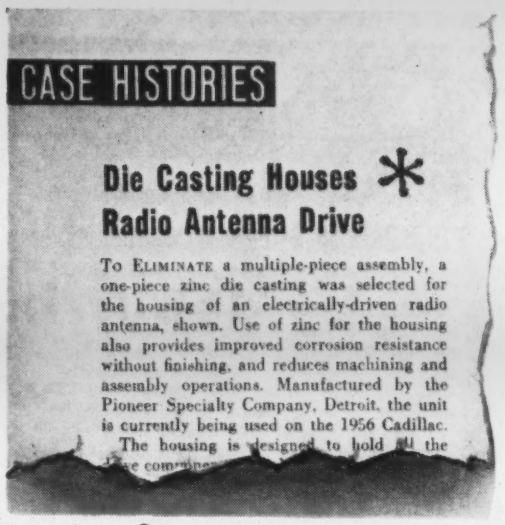
The items fall into two categories — indications of general areas, and specifically defined problems. A summary of those areas and problems that involve the development of materials follows:

Heat dissipation in electronic assemblies—The high incident temperatures in small electronic devices require a new means of cooling. A static device or material is needed to serve as a heat rectifier to provide unidirectional transfer of heat or as a unidirectional heat exchanger.

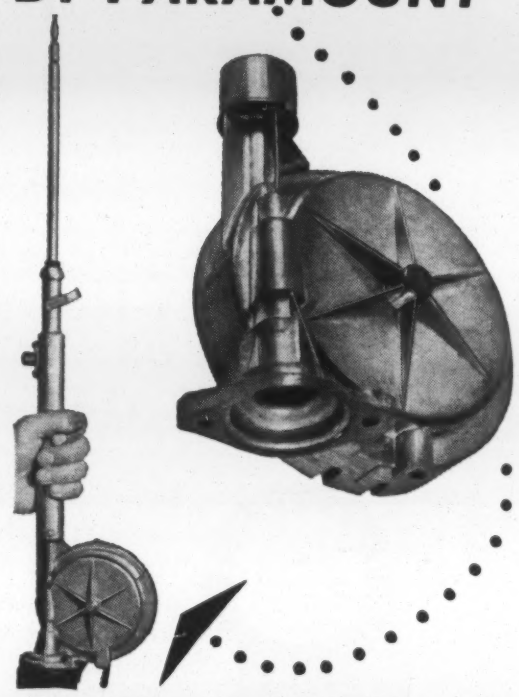
Encapsulating material—A potting or encapsulating material for use with transistors that will provide an assembly having high heat dissipation and mechanical ruggedness. The material must not cause chemical decomposition or affect the performance of transistor materials.

Low temperature battery—An alkaline-zinc-mercuric oxide battery system that will operate satisfactorily at low temperatures.

Solid electrolyte battery — A solid, ion conducting material


CASE HISTORIES
Die Casting Houses Radio Antenna Drive
To ELIMINATE a multiple-piece assembly, a one-piece zinc die casting was selected for the housing of an electrically-driven radio antenna, shown. Use of zinc for the housing also provides improved corrosion resistance without finishing, and reduces machining and assembly operations. Manufactured by the Pioneer Specialty Company, Detroit, the unit is currently being used on the 1956 Cadillac.
The housing is designed to hold all the

DIE CASTING BY PARAMOUNT



5 REASONS WHY

A DIE CASTING PRODUCED A BETTER PART FOR LESS

1. **Eliminated a multi-piece assembly.**
2. **Improved resistance to corrosion.**
3. **Eliminated finishing.**
4. **Reduced machining operations.**
5. **Reduced assembly operations.**

The total result is a part produced of the *finest quality* at the *lowest possible cost!* Call in a PARAMOUNT sales engineer today, let him tell you the complete story.

*PARTIAL REPRINT—
"ELECTRICAL MANUFACTURING"
April, 1956

WRITE FOR FREE
DESCRIPTIVE BROCHURE

ALUMINUM ZINC MAGNESIUM
Paramount
DIE CASTING COMPANY
ST. JOSEPH 23, MICH.

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For more information, Circle No. 547 ➤

that will function as the electrolyte of an electrochemical cell and can be used in conjunction with an electrode couple having an emf in excess of 1 v. Such a cell should deliver a practical current density of 100 microamp per sq cm or less between −40 and 165 F and have a long shelf life.

Battery sealing material — A dry battery cell sealing material that will effectively prevent moisture loss over a temperature range of −65 to 1600 F.

Plastics embossing technique— Method of embossing a lenticulation of nonspherical shape onto plastics sheets measuring 5 x 5 ft or more. The lenticulations must be perfectly regular with no overlapping or gaps between adjacent lenticulations. Size of individual elements would be approximately 1/16 in. or less.

Protective coatings—A method of coating or otherwise protecting the surfaces of transistors so as to prevent deterioration with life at temperatures ranging from −40 to approximately 400 F.

High resistivity silicon—Equipment to grow large, single crystal, high resistivity silicon by a method that does not use a crucible.

Metal-to-metal bond inspection techniques—A means of inspecting structural joints formed by bonding the components with resin or other types of metal-to-metal glues.

Because of the diminishing supply of natural quartz it is also necessary that synthetic materials be developed for frequency control devices. Synthetic quartz and all piezoelectric materials which offer possibility as a substitute for natural quartz should be investigated.

Possible solutions to these problems should be submitted to National Inventors Council, Office of Technical Services, Dept. of Commerce, Washington 25, D.C.

(news of Engineers on p 214)

For more information, turn to Reader Service Card, Circle No. 427

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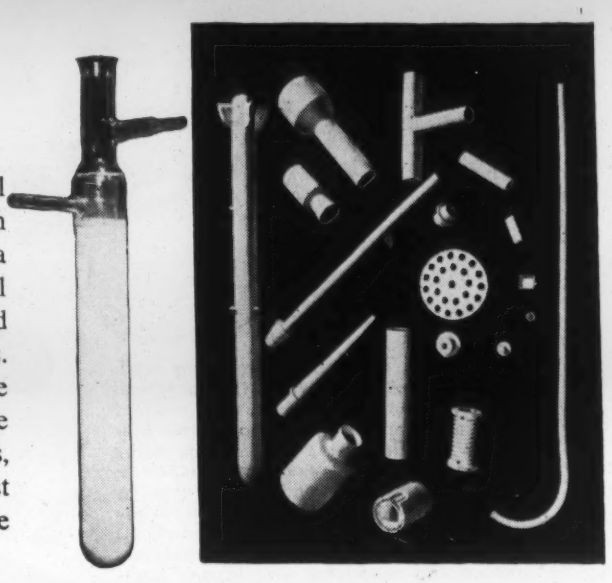
SHAPES THE CERAMIC . . .

to Suit Your PARTICULAR REQUIREMENTS

• Our business is to create special ceramic bodies or shapes for research or production use. You may need a material to resist abrasion or chemical action, or stand extreme heat or cold . . . or other special requirements. Ceramics may be the answer! We study your drawings and needs. We develop special dies, molds, designs, bodies, mixes and even processes just for your application. Our people are trained for it. Contact us today!



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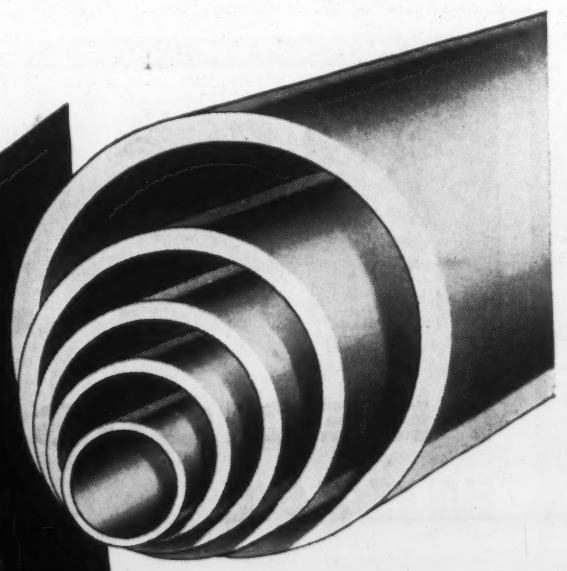
Send us a sketch of your application. Your inquiry is special to us!

Simplify and improve your designs



PYRAMID Plastic Tubing gives you these advantages . . . . . CUTS COST

- Easier to Work With
- Requires Less Space
- Lighter in Weight
- Dimensional Stability
- Better Performance
- Longer Life
- Greater Dependability

We manufacture tubing as small as .020 I.D. with .015 wall from vinyl, cellulosics, styrenes and Saran, in most sizes and materials.

Pyramid Plastic Extrusions are now being used in thousands of products because of their cost and functional features. If you are using plastics, it will pay you to check your designs and investigate the savings possible by using Pyramid Plastic Extrusions.

PPI

Send specifications for engineering recommendations and quotation

PYRAMID PLASTICS, INC.

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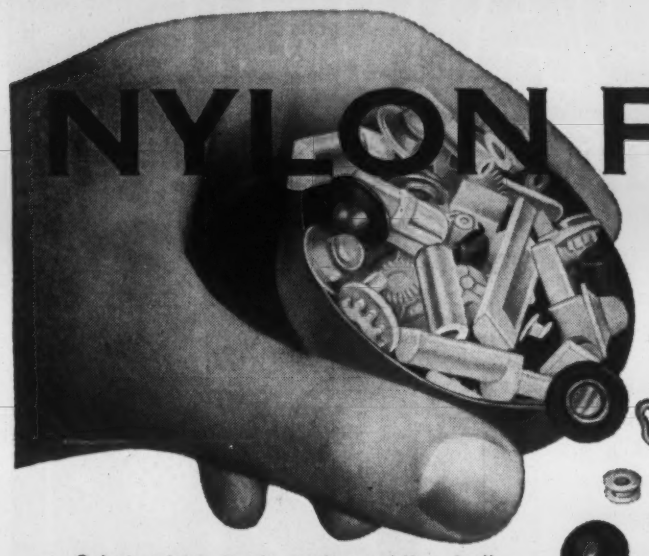
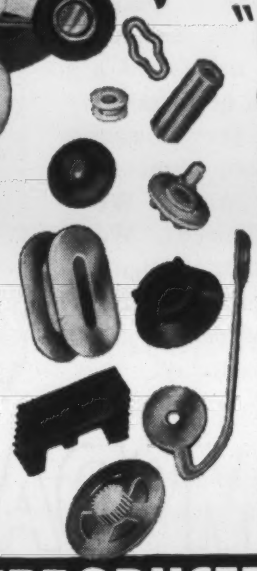
For more information, turn to Reader Service Card, Circle No. 442

For more information, turn to Reader Service Card, Circle No. 479

new designs on the board?

GRC
TINY MOLDED
NYLON PARTS
may be the difference between "problems" and profits!





Gries' unique single cavity molding facilities are *flexible*—provide the practical answer to countless problems of product design and improvement. No matter how tiny, or how intricate, GRC molds nylon parts to meet your exact specifications, with precise tolerances and uniform quality. And, because GRC methods are completely automatic, costs are surprisingly low—GRC tiny nylon parts are produced completely trimmed and ready for use, in one high-speed, money-saving operation!

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Send prints for quotation.

GRC MOLDS ALL THERMOPLASTICS SWIFTLY, DEPENDABLY, ECONOMICALLY!

Automatic Continuous and Individual Inserts! Single Parts!

Quick deliveries on quantities of 25,000 to millions.

MAXIMUM SIZE
.03 ozs.—1¼" long.
NO MINIMUM SIZE!
LOW MOLD COSTS!

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World's Foremost Producer of Small Die Castings

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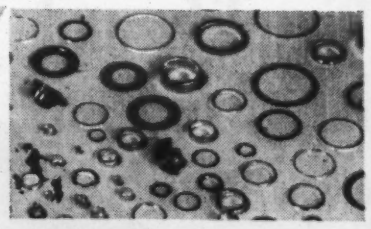
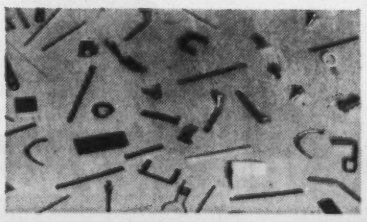
NEY'S SMALL PARTS PLAY A BIG PART IN PRECISION INSTRUMENTS • NEY'S SMALL PARTS

NEY





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ENGINEERED CONTACTS, SLIP RINGS & ALLOYS

Ney designs and makes to customers' specifications sliding contacts, slip rings and assemblies, commutator segments and assemblies, brush and brush holder assemblies, and precious metal resistance wire. Consult Ney's Engineering Dept. and find out how precious metals can improve your products.

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Specialists in Precious Metal Metallurgy since 1812

Ney has just built this modern new plant to give you even better products and better service.

For more information, turn to Reader Service Card, Circle No. 410

News OF INDUSTRY

ENGINEERS

Edward J. Cassidy has been promoted to manager of the Defense Div., Servel, Inc.

Frank C. Riecks has joined Sutter Products Co. as executive vice president.

Martin Aaron has been appointed assistant to the president of Sam Tour & Co., Inc., and its affiliate, American Standards Testing Bureau, Inc.

Charles H. Shelton is now chief metallurgist of White Motor Co.

Dr. R. M. Burns, senior scientific advisor to Stanford University Research Institute, has been awarded the Acheson Medal of the Electrochemical Society for 1956.

Justus T. Vollbrecht, president of Energy Control Corp., was elected national president of the Instrument Society of America during its conference and exhibit in New York.

Clarence G. Bauer is manager of quality control, and **Frank H. Brown** manager of production planning and material control for Chrysler Corp.'s Stamping Div.

James J. Welker has been elected vice president in charge of operations, Clevite Corp.

Dr. Wiliam D. Walther has been made head of Dayton Steel Foundry Co.'s new Research and Development Div.

Robert Logie is now executive vice president of Firth Sterling, Inc., and has been elected to the board of directors.

Joseph A. Despres has been appointed administrative assistant to the vice president for engineering, Ford Instrument Co.

John H. Bouwmeester has been named executive vice president, General Ceramics Corp.

Charles E. Bagwell has been named chief engineer at Hanson-Van Winkle-Munning Co.

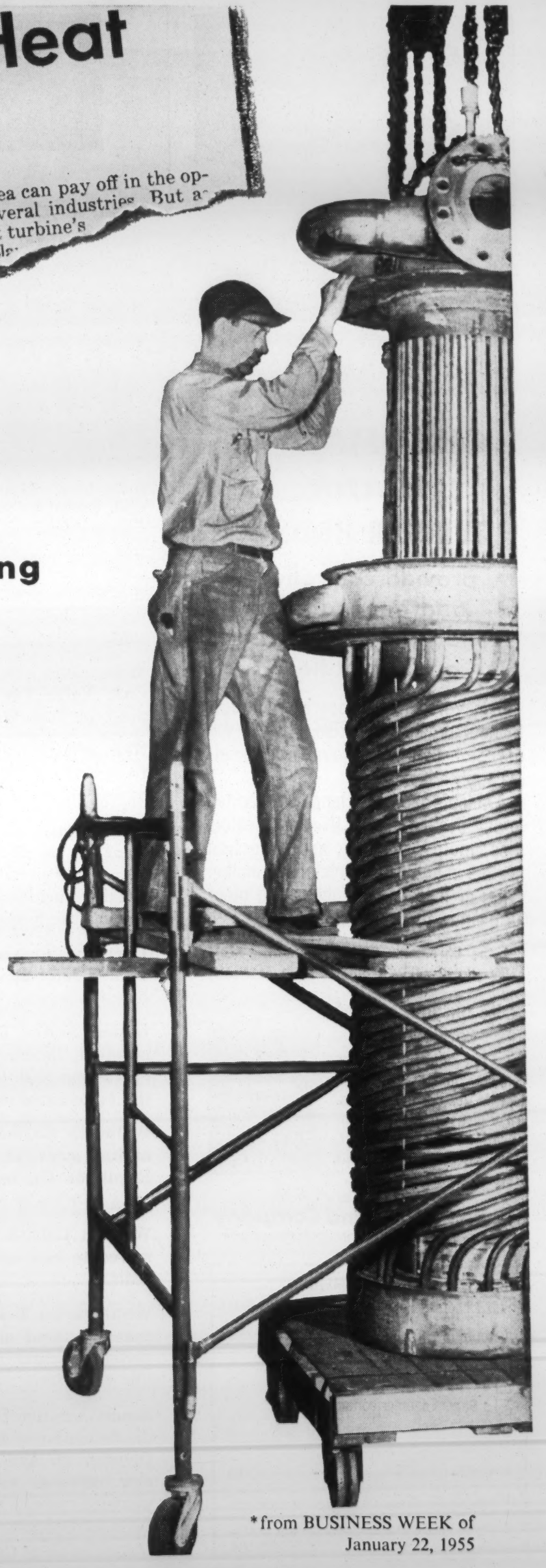
James R. Ireland is now director of research and engineering, Indiana Steel Products Co.

(news of Companies on p 216)

Concentrated Heat for Industry*

Scientists and engineers have done a tremendous amount of work, over the past 10 years, with new techniques in burning fuels. Most of their work has been aimed at the goal of making airplanes and rockets fly faster. Now, as this illustration shows, industry is picking up some of the techniques for its own use.

and smaller area can pay off in the operations of several industries. But a[s] it stands, a jet turbine's [fuel] too rich for a pla[nt] bine's f[uel]



...built around

Carpenter Stainless Tubing

for Long Life!

This unique type compact heat exchanger has found ready acceptance as a highly efficient and dependable source of hot air or gas at pressures up to 300 psi and temperatures to 1200°F. Carpenter Stainless Tubing met every requirement of the manufacturer—superior strength at high pressures and temperatures, easy fabrication, uniform expansion, oxidation resistance and long, maintenance-free performance. That's why Carpenter Stainless Tubing is used exclusively for the straight tube and coiled fin-tube bundles, both shown at right partially assembled.

Any heat transfer equipment worth building or using is worth Carpenter quality. It costs no more . . . because all full-finished Carpenter Stainless Tubing meets the high and uniform quality requirements for heat exchanger applications. And you are sure of getting the highest possible degree of perfection in Carpenter tubing because it must pass the most exacting and thorough non-destructive test ever applied to stainless tubing.

Call your nearest Carpenter Distributor or Branch Office to give your equipment the benefit of better-than-ever Carpenter Stainless Tubing.

MEMBER STEEL TUBE INSTITUTE

The Carpenter Steel Company, Alloy Tube Division, Union, N. J.

Export Dept.: The Carpenter Steel Co., Port Washington, N.Y.—"CARSTEELCO"

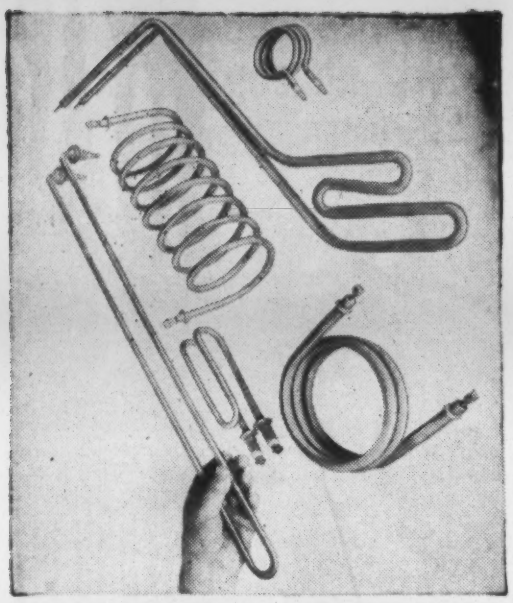
Carpenter

more than corrosion resistance

Stainless Tubing & Pipe

*from BUSINESS WEEK of January 22, 1955

For more information, turn to Reader Service Card, Circle No. 513



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provide controlled and dependable conduction, convection or radiant heat

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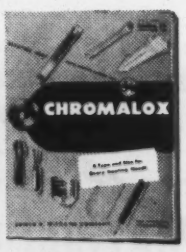
Available in straight lengths or formed to any desired shape. Used for heating dies, molds, platens; as immersion heaters in liquids, soft metal and molten salts; or in ovens, air ducts and other air heating applications.

Let the Chromalox Sales Engineering staff solve your heating problems . . . electrically

Write for your copy of Catalog 50

—for full information on the complete line of Chromalox Electric Heaters and controls.

For ideas on additional applications of electric heat, request Booklet F1550—"101 Ways to Apply Electric Heat."



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For more information, Circle No. 412

News OF INDUSTRY

COMPANIES

Anchor Metal Co. has moved its offices and factory to more spacious quarters at 966 Meeker Ave., Brooklyn 22, N. Y.

Electric Storage Battery C . has purchased the fixed assets of **Dibb Manufacturing Co., Inc.** The Dibb assets will be absorbed into the company's Jordan Electric Products Div.

Gregory Industries, Inc., has announced establishment of a $1500 cash award to be presented annually for the most outstanding contribution to the further development of electric arc stud welding. Entries for the first competition must be postmarked before midnight, June 30, 1957.

Minneapolis - Honeywell Regulator Co.'s Valve Div. will erect a new plant at Fort Washington, Pa.

New Plastic Corp. has acquired **Lansco Die Casting Co.** as a wholly owned subsidiary.

Penn-Plastics Corp. has announced plans for an addition to its plant in Glenside, Pa., to house its injection molding facilities and allow for enlarging the finishing department.

Townsend Co. has purchased controlling interest in **Impact Products, Inc.**

United States Plywood Corp. has acquired **Barash Co., Inc.** Barash operations will be continued under the same name and management.

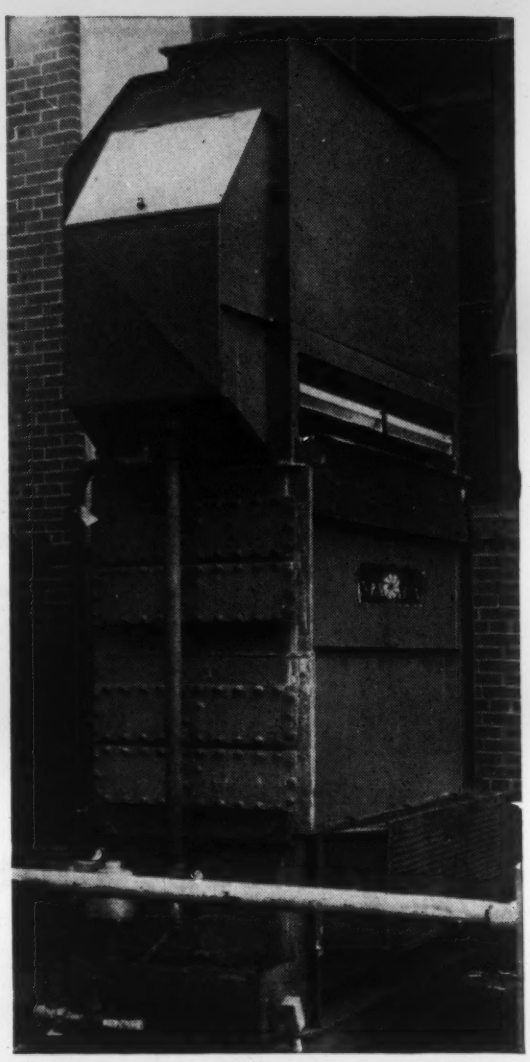
Walworth Co. has acquired all the capital stock of **Grove Valve and Regulator Co.** and **Grove Controls, Inc.**

Western Gold & Platinum Co. has moved to new quarters in Belmont, Calif.

Westinghouse Research Laboratories has announced plans to add a new nuclear research reactor to its scientific facilities.

Bendix Aviation Corp. has announced the formation of the Bendix Systems Division at Ann Arbor, Mich. The new division will concentrate on weapons systems requirements of the Dept. of Defense.

(more news of Companies on p 218)



You Get Better Results in HEAT TREATING!

Use the NIAGARA AERO HEAT EXCHANGER to control the temperature of your quench bath and you remove the heat at its rate of input, always quenching at the exact temperature that will give your product the best physical properties.

The Niagara Aero Heat Exchanger transfers the heat to atmospheric air by evaporative cooling. It extends your quenching capacity without using extra water. It pays for itself with water savings.

You can cool and hold accurately the temperature of all fluids, gases, air, water, oils, solutions, chemicals for processes and coolants for mechanical and electrical equipment. With the Niagara Aero Heat Exchanger you have closed system cooling, free from dirt and scale.

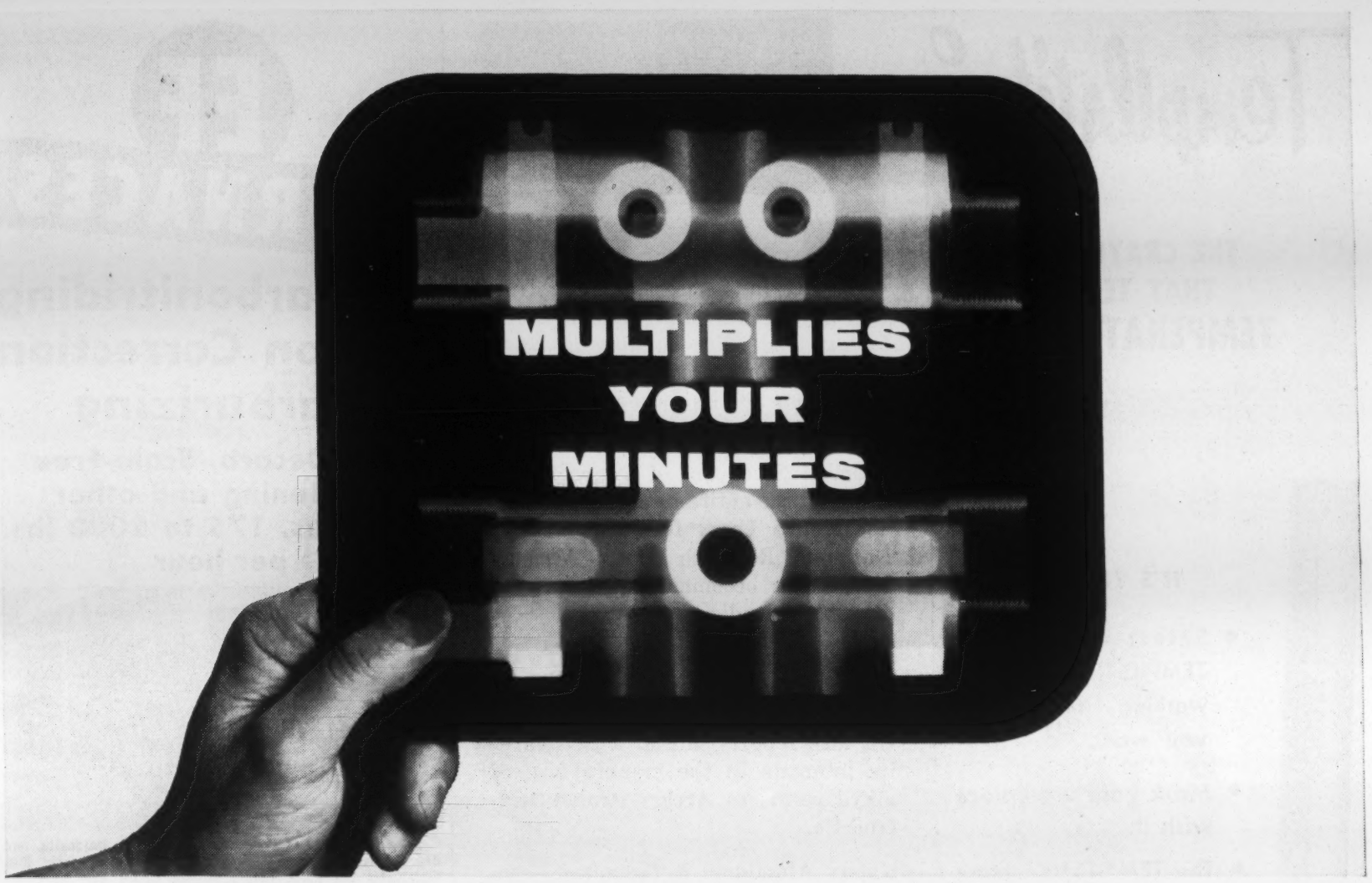
Write for Bulletin No. 120

NIAGARA BLOWER COMPANY

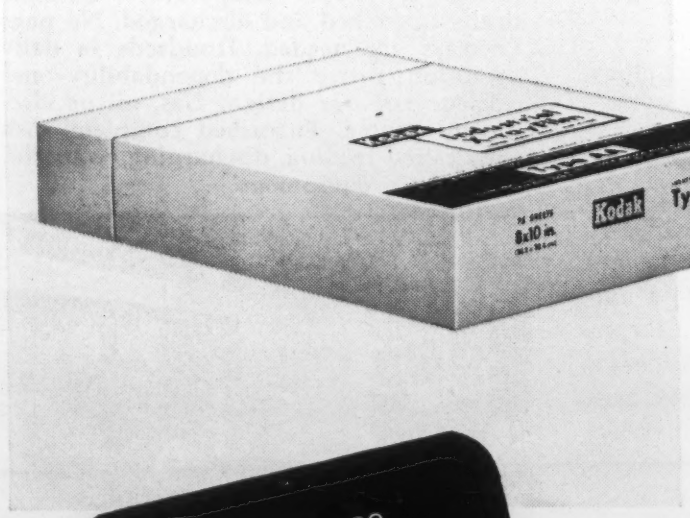
Dept. M.M., 405 Lexington Avenue
NEW YORK 17, N. Y.

District Engineers in Principal Cities of U. S. and Canada

For more information, Circle No. 510



New Kodak Industrial X-ray Film, Type AA



When you're faced with the need for quantities of high-quality work, Kodak's new Industrial X-ray Film can be an outstanding find.

Because of its greatly increased speed, exposure times can be cut, and more production realized with existing x-ray equipment and gamma ray sources.

While this new film ranges up to more than twice as fast, it still has the fine sensitivity characteristics which made Kodak Type A the most widely used x-ray film in industry.

Kodak Industrial X-ray Film, Type AA, extends the service of present radiographic equipment, saves time, produces quality results. Have your x-ray dealer or Kodak Technical Representative show you how.

EASTMAN KODAK COMPANY
X-ray Division Rochester 4, N. Y.

Read what the new Kodak Industrial X-ray Film, Type AA, does for you:

- Reduces exposure time—speeds up routine examinations.
- Provides increased radiographic sensitivity through higher densities with established exposure and processing technics.
- Gives greater subject contrast, more detail and easier readability when established exposure times are used with reduced kilovoltage.
- Shortens processing cycle with existing exposure technics.
- Reduces the possibility of pressure desensitization under the usual shop conditions of use.

Kodak
TRADE-MARK

For more information, turn to Reader Service Card, Circle No. 409

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THE CRAYONS THAT TELL TEMPERATURES

IT'S THIS SIMPLE

- Select appropriate TEMPILSTIK° for the working temperature you want.
- Mark your workpiece with it.
- The TEMPILSTIK° mark melts as soon as its temperature rating has been reached.

Accuracy within 1% of rated melting point.

Also available as TEMPILAQ° (liquid form) and TEMPIL° PELLETS

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Send information on:

☐ TEMPILSTIK° ☐ TEMPILAQ° ☐ TEMPIL° PELLETS
☐ Send booklet "How Temperatures are Measured"
☐ Send sample pellets for _____°F temperature

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State_____

For more information Circle No. 395

News OF INDUSTRY

Croname, Inc., has begun construction of a new multi-million dollar factory and office building in Niles, Ohio. Croname anticipates expanding production of its decorative metal parts and printed circuits by 50%.

Crucible Steel Co. of America has acquired the entire interests in **Vacuum Metals Corp.** formerly held by National Research Corp. Vacuum Metals now becomes a wholly owned Crucible subsidiary.

General Electric Co.'s Atomic Power Equipment Dept. has announced completion of its move to San Jose, Calif. GE also reports sale of a portion of its interests in the manufacture of alkyd resins to **Archer-Daniels-Midland Co.**

Kaiser Aluminum & Chemical Corp. has acquired the **Hokin Aluminum Co.** extrusion plant at Dolton, Ill.

Kaiser Gypsum Co., Inc., has purchased the physical assets of **Fir-Tex Insulating Board, Inc.** Fir-Tex will become the Insulating Board Div. of Kaiser Gypsum.

Kelsey-Hayes Wheel Co. has acquired **Koldweld Corp.**

James F. Lincoln Arc Welding Foundation has announced a new machine design competition offering $25,000 in 26 awards for the best papers describing the design of welded machines and equipment used in construction, mining and certain processing industries, and for jigs, fixtures and tooling in all types of industries.

Lockheed Aircraft Corp. is constructing an engineering center near Marietta, Ga.

Lord Manufacturing Co. has established a Special Products Div. for research, manufacturing and marketing of adhesives, chemicals and other polymers.

McGregor-Michigan Corp. has begun operations at its new heavy fabricating plant in Detroit, Mich.

National Starch Products, Inc., has acquired **Granite Board, Inc.**

Parker Stamp Works, Inc., has changed its corporate name to **Parker-Hartford Corp.**

(news of Societies on p 220)

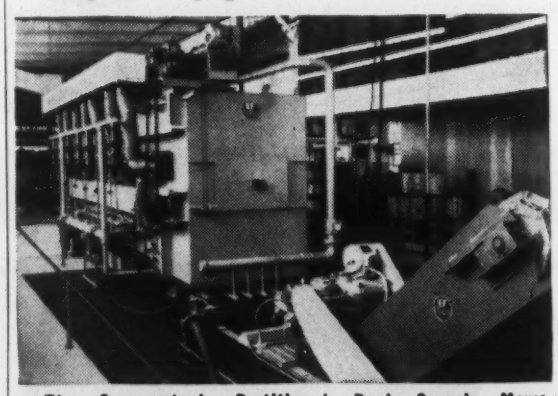
EF FURNACES

For Carbonitriding Carbon Correction Carburizing

Non-Decarb, Scale-Free Hardening and other Processes, 175 to 2000 lbs. per hour

EF Gas Fired Radiant Tube Combination Hardening and Dry Cyaniding Unit Fitted with an Automatic Feeder that Distributes the Parts Evenly on the Chain Belt Conveyor; and a Dual Quench.

The EF chain belt conveyor furnace is one of the most satisfactory continuous heating units yet devised for treating small and medium size parts. The material is loaded onto cast link conveyor belt; carried through the furnace; heated uniformly to proper temperature; automatically quenched and discharged. No pans or trays are needed. Hundreds in daily operation prove the dependability and efficiency of our design. Gas, oil or electrically heated. Furnished complete with any desired feeding, discharging or special atmosphere equipment.



The Conveyorized, Partitioned Dual Quench Moves Laterally to Permit either the Complete Oil or the Water Quenching Equipment to be Positioned under the Sealed Furnace Discharge.

BULLETIN No. 461 shows typical installations of EF Gas-fired, Oil-fired and Electric Furnaces
Send for a copy today!

THE ELECTRIC FURNACE CO.
Salem - Ohio
GAS-FIRED, OIL-FIRED AND ELECTRIC FURNACES FOR ANY PROCESS, PRODUCT OR PRODUCTION

Canadian Associates
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LOOK AHEAD

TO FEWER MAINTENANCE DELAYS WITH CONTROLS BY REMINGTON RAND

Many arms are needed to perform the functions of maintenance. But, how much easier it is to perform when you can control and direct these arms.

Look ahead maintenance is preventive maintenance ... a visible system of planned controls that schedules maximum productivity from a minimum of time and money expenditure.

Consult your Remington Rand maintenance specialist for a cost-saving system that best fits your requirements. He has simplified controls for visibly charting and coordinating your maintenance operation. Write Room 1167, 315 Fourth Avenue, New York 10, N. Y. Ask for free booklet X1383 — "Assured Equipment Productivity Through Maintenance Management."

Hope to see you at the Plant Maintenance and Engineering Show in Cleveland — January 28-31.

Remington Rand
DIVISION OF SPERRY RAND CORPORATION

For more information, turn to Reader Service Card, Circle No. 399

NEW

Luster-on®

52 POWDER

PROTECTS and BRIGHTENS ZINC at LOWEST COST YET

LUSTER-ON 52 POWDER *is a low, low priced single dip, no-leach conversion coating for zinc plated surfaces.*

LUSTER-ON 52 POWDER was recently developed by The Chemical Corporation for automatic equipment where facilities are not available for added leaching and rinsing.

LUSTER-ON 52 POWDER gives a bright bluish hue; provides lasting corrosion protection against staining, tarnishing and white powder products.

LUSTER-ON 52 POWDER can *now* be used in cases where cost has prohibited use of chromates in the past. For instance, electrical conduit, conduit boxes, screws and builder's hardware, tools, electronic parts, air conditioning parts, automotive parts, cheap toys.

LUSTER-ON 52 POWDER is not only low, low in price, but eliminates expensive handling, space-consuming storage and carboy deposits.

Still available, of course — time-tested Luster-On liquid dips and coatings for all your needs.

Data Sheets and Prices on Request. Send in part for free processing.

West Coast: Crown Chem. & Engr. Los Angeles & San Francisco

Canadian Licensee: Alloycraft Ltd. Montreal

THE *Chemical* CORPORATION

67 Waltham Ave. • Springfield 9, Mass.

For more information, Circle No. 443

News OF INDUSTRY

SOCIETIES

American Welding Society honored leaders in the field of welding for outstanding achievements at its national fall meeting. George E. Linnert, head of welding research at Armco Steel Corp. Laboratories, presented the Adams Honor Lecture on the subject, "The Welding of Precipitation Hardening Stainless Steels." The Samuel Wylie Miller Memorial Medal was presented to Clarence E. Jackson, research metallurgist, Metals Research Laboratories of Linde Air Products Co., for researches in the field of welding metallurgy that have contributed significantly to the art of welding. H. C. Ludwig, research engineer, Westinghouse Research Laboratory, was awarded the J. F. Lincoln Gold Medal for a paper judged as the most original contribution to the advancement and use of welding and published in *The Welding Journal.* His winning article was entitled, "Nitrogen Effects in Argon-Arc Welding Atmosphere."

AWS has awarded cash prizes to two engineering students for their outstanding welding articles which appeared in undergraduate student publications. First prize of $200 was awarded to Lee E. Allgood, University of Michigan, for his paper, "Welding for Modern Processing," published in the *Michigan Technic.* Second prize of $150 went to George L. Neal, University of Denver, for his paper, "Economical Hard-Facing with Cast Iron Electrodes," which appeared in the *Denver Engineer.*

Gray Iron Founders' Society recently presented the following awards in its 1956 Redesign Contest: top award of $500 to J. E. Rohrer, New Holland Machine Div. of Sperry Rand Corp.; second prize of $250 to R. C. Mueller, Universal Foundry Co.; and third prize of $100 to V. Gleasman of Cleveland, Ohio. Receiving honorable mention in the competition were William S. Thomas, Emmaus Foundry & Machine Co., and Norman J. Petitte, Superior Foundry Co. The Redesign Contest is conducted each year to give recognition to engineers and designers who have successfully redesigned machinery components for production in gray iron.

(more news of Societies on p 222)

Do You Buy Graphite Components?

- Do you know that a graphite material of construction is available which is impermeable and unaffected by practically all corrosives at *any* temperature . . . or that another carbon-graphite material possesses a hardness as great as that of glass?

- Both of these materials are exclusive developments of Graphite Specialties Corporation, a recognized leader in the production of special carbon and graphite components.

- In addition to these two outstanding materials, Graphite Specialties Corporation regularly produces components with specially required properties of density, purity, strength, permeability, chemical resistance and machining characteristics.

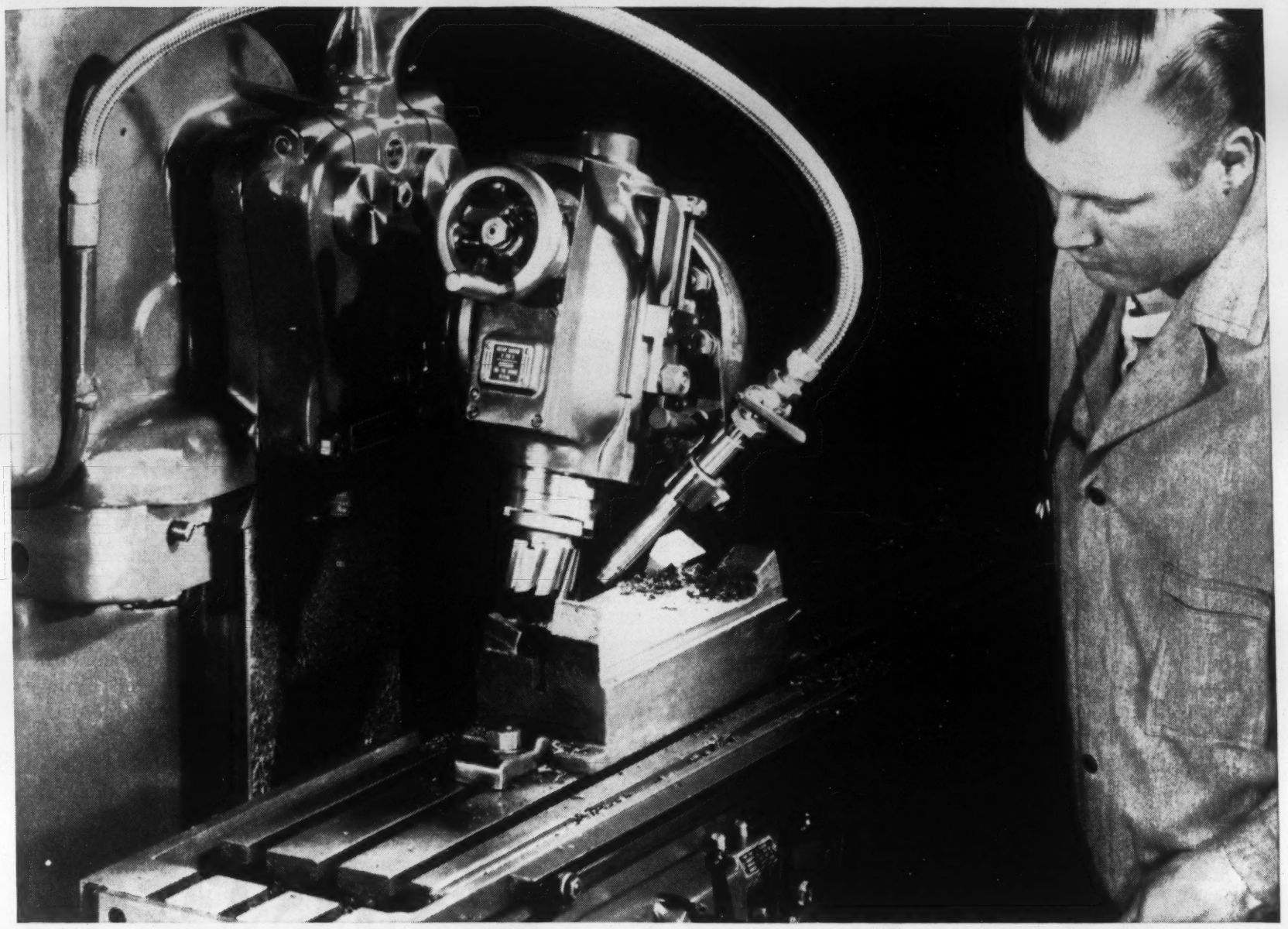
- Graphite Specialties Corporation components can be produced sufficiently pure for use as a moderator in atomic reactors, to provide exceptionally low erosion rates in rocket nozzles—for use with chlorine at *any* temperature—as crucibles for transistor crystal growth—in difficult metallurgical and chemical applications, as well as for component parts for mechanical equipment.

- Molding, extruding and machining facilities are available for short runs or high production.

- Write today for information relating to your specific component requirements to Graphite Specialties Corporation, 64th Street at Pine Avenue, Niagara Falls, New York.

For more information, Circle No. 431

MALLORY·SHARON reports on TITANIUM



The titanium parts you design can be readily machined

• Titanium offers outstanding design advantages—a high strength-to-weight ratio, and exceptional resistance to corrosion in media where many other metals are useless. These advantages can now be realized without paying a penalty in production time.

Present grades of unalloyed titanium machine similar to 18-8 stainless steel. The alloy grades machine somewhat harder but do not approach the difficult-to-machine high temperature alloys. For the usual industrial application of titanium, where corrosion resistance is the major advantage sought, the readily-machined unalloyed grades are usually the best choice.

Mallory-Sharon guarantees that MST titanium and titanium alloy mill products contain no more than 1/10 of 1% carbon. This avoids the formation of hard carbides which greatly reduce machineability.

For bulletin on titanium machining recommendations, please write Dept. G-1.

MALLORY-SHARON TITANIUM CORPORATION, NILES, OHIO

MALLORY Ti® SHARON

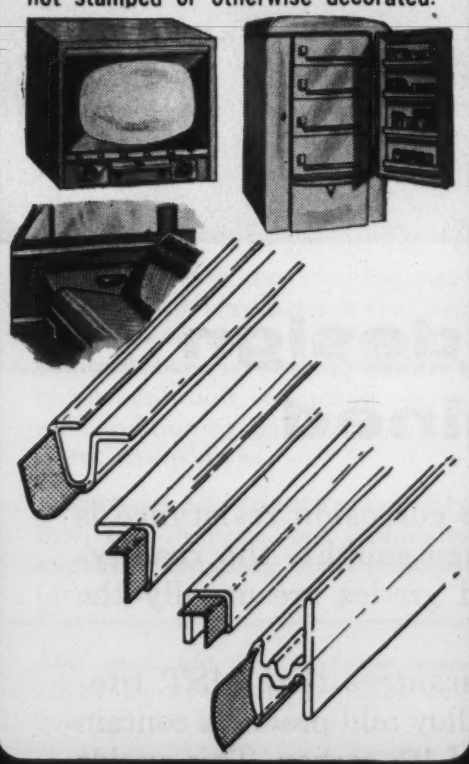
For more information, turn to Reader Service Card, Circle No. 419

ANCHOR PLASTICS EXTRUSION NEWS

CHROME-LIKE TRIM

The latest development is the possibility of obtaining really metallic looking extrusions. Polished metal foil embedded in low cost thermoplastic extrusions gives appearance of highly polished chrome. Can also be specified in gold, copper, brass or to match any other metallic finish and color.

Finish cannot corrode, will not wear or scratch off. Extrusions can be printed, hot stamped or otherwise decorated.



We extrude to YOUR specifications any SHAPE, ROD, TUBE or MOULDING; also CURVED EXTRUSIONS*, FABRICATED EXTRUDED PARTS, in any of 12 plastic materials.

- Extrusion dies made in our tool room, usually between $45-$200
- Send us your prints for quotation
- Write for your copy of Extruded Plastics on company letterhead

PAT.

ANCHOR PLASTICS CO., INC.
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Long Island City 6, N. Y.

For more information, Circle No. 397

News of Industry

Metal Powder Assn., at its 1956 fall meeting, presented Robert Lindley Ziegfeld with a testimonial resolution in honor of his service as secretary and treasurer of the Association for nine years until its establishment as an independent organization last July. At that time the MPA became an independent trade association for the metal powder industry with Kempton H. Roll serving as executive secretary.

Metal Treating Institute presented the Annual MTI Achievement Award to A. E. Gurley and C. R. Hannewald of Chrysler Corp. for joint authorship of the article, "Development and Application of the Iso-Hardness Diagram," which appeared in the May-June, 1956 issue of the Institute's publication, *Metal Treating*.

Pressed Metal Institute has elected the following national officers: president—Bruce Krasberg, president, R. Krasberg & Sons Mfg. Co., and vice president, Great Lakes Copper Mines, Ltd.; first vice president — Clint Stryker, president, Maysteel Products, Inc.; second vice president—Carter C. Higgins, president, Worcester Pressed Steel Co.; secretary and treasurer — Bryant Gemmill, treasurer, American Stamping Co.

American Die Casting Institute has elected Gordon C. Curry a director to fill the board vacancy left by the resignation of William J. During. Mr. Curry is Eastern sales manager of Precision Castings Co.

American Institute of Mining, Metallurgical and Petroleum Engineers has named Dr. Augustus B. Kinzel as president for one year beginning in February, 1958. Dr. Kinzel is vice president of research, Union Carbide and Carbon Corp. Vice presidents taking office in 1958 are: Edmund C. Babson, manager, Canadian Div., Union Oil Co. of Calif.; and Roger V. Pierce, consulting mining engineer.

American Lithium Institute has been established for the purpose of conducting research on lithium and its compounds and to act as an agency for the correlation and dissemination of technical information on lithium. Marshall Sittig, formerly of Ethyl Corp., has been elected president and managing director of the Institute.

(news of Meetings on p 224)

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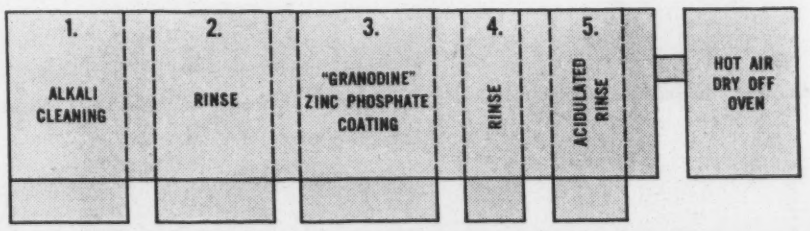
GRANODIZING PROCESS PRODUCES STEEL DRUMS FREE OF GREASE, DIRT, SCALE—AND RUST INHIBITED

Photo courtesy United States Steel Products Division, U.S. Steel Corp., Camden, N.J.

TREATMENT OF UNASSEMBLED SHELL, head and bottom drum sections is done in this power spray washer. Conveyer carries drum parts through five cleaning, rinsing and phosphate-coating stages. Drying oven removes moisture from parts prior to painting. Finish is durable and better looking.

5-stage process uses Granodine® to provide better paint adherence and underfinish rust resistance



1-YEAR EXPOSURE TO WEATHER proves the effectiveness of the phosphate coating. Untreated drum at right is rusted and pitted. Phosphate-coated drum at left has retained its finish. Coating provides a firm, durable bond for paint, retards corrosion.

In the Granodizing process, drums fabricated from steel are both freed from grease, oil and dirt and protected by a rust-inhibiting nonmetallic crystalline zinc phosphate coating over the entire inner and outer surfaces. Residues and contaminants are completely removed to assure high product purity.

Cleaning and phosphate-coating operations are done in a large high-speed power spray washer. Continuous spray phosphatizing machines such as this are used where large quantities of similar products are treated. Since Granodizing is effective only on greasefree surfaces, such machines must provide the steps necessary to remove all impurities. This is done by passing the work through five cleaning and rinsing stages.

The process as developed is another example of the technical assistance which ACP offers its customers. Our Engineering and Service Departments not only recommend the proper equipment, but instruct plant personnel in its operation, and check samples of the finished product in our own Quality Control Laboratory.

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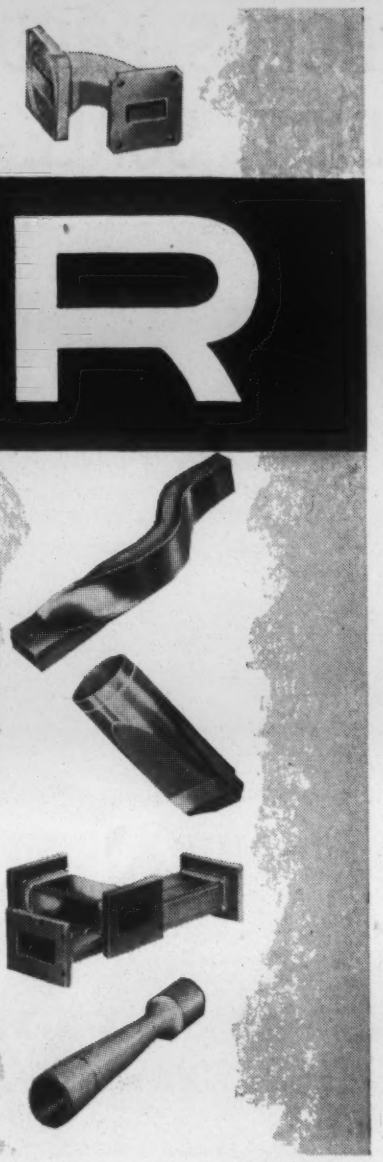
GAR



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News OF INDUSTRY

MEETINGS

MIDWEST WELDING CONFERENCE, sponsored by Armour Research Foundation and Chicago Chapter of American Welding Society. Chicago. Jan 30-31.

AMERICAN SOCIETY FOR TESTING MATERIALS, committee week. Philadelphia. Feb 4-8.

GRAY IRON FOUNDERS' SOCIETY, committee week and spring meeting. Philadelphia. Feb 4-8.

SOCIETY OF THE PLASTICS INDUSTRY, annual Reinforced Plastics Div. conference. Chicago. Feb 5-7.

MALLEABLE FOUNDERS' SOCIETY, technical and operating conference. Cleveland. Feb 7-8.

AMERICAN FOUNDRYMEN'S SOCIETY, Southeastern Regional Conference, Birmingham, Ala. Feb 21-22.

AMERICAN INSTITUTE OF MINING, METALLURGICAL AND PETROLEUM ENGINEERS, annual meeting. New Orleans. Feb 24-28.

SOCIETY OF AUTOMOTIVE ENGINEERS, passenger car, body and materials meeting. Detroit. Mar 5-7.

PRESSED METAL INSTITUTE, annual spring technical meeting. Cleveland. Mar 6-8.

NUCLEAR CONGRESS. Philadelphia. Mar 11-15.

NATIONAL ASSN. OF CORROSION ENGINEERS, annual conference and exhibition. St. Louis. Mar 11-15.

STEEL FOUNDERS' SOCIETY OF AMERICA, annual meeting. Chicago. Mar 18-19.

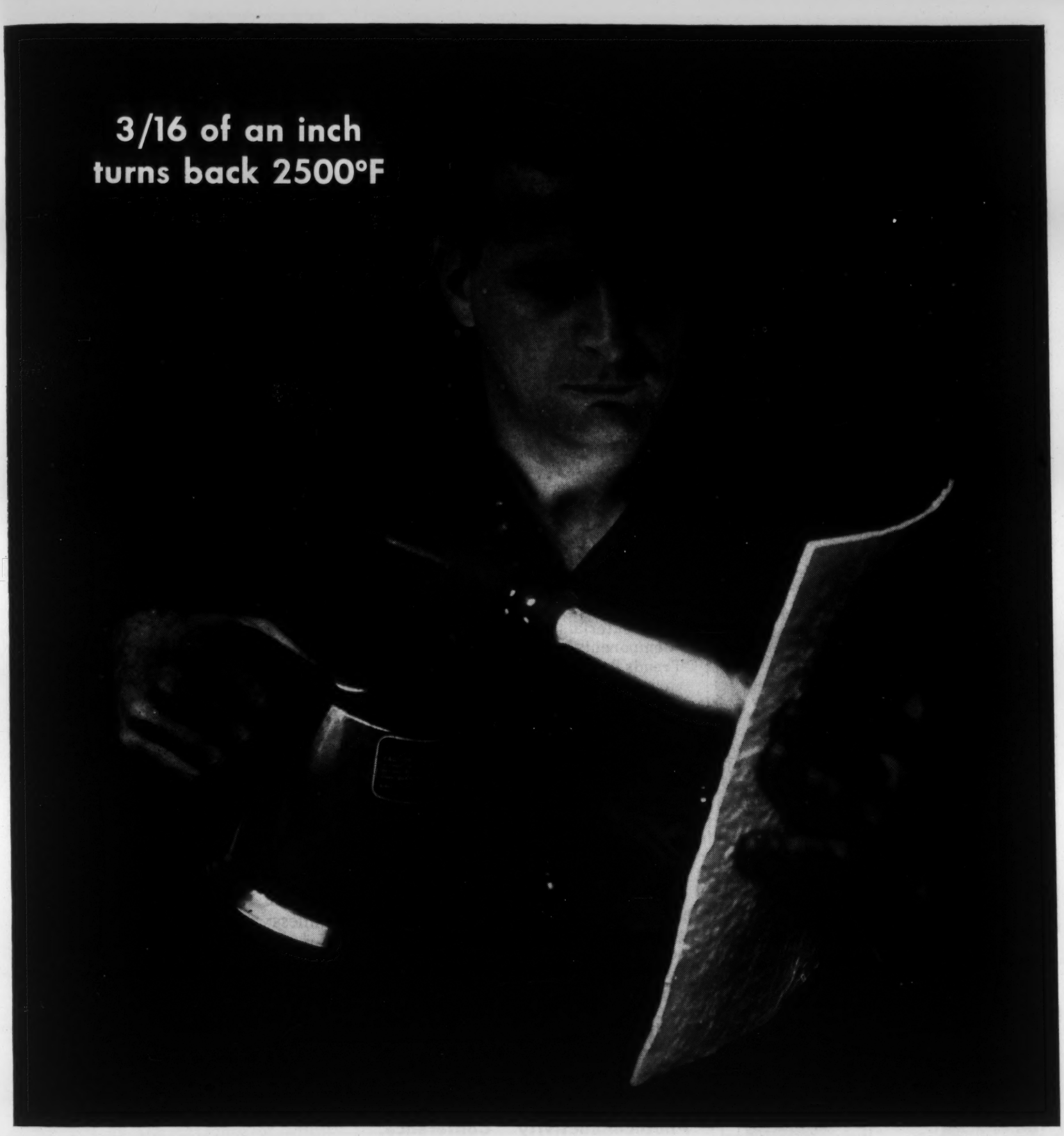
AMERICAN INSTITUTE OF MINING, METALLURGICAL AND PETROLEUM ENGINEERS, regional meeting on drawing-quality steels. Detroit. Mar 18-19.

SOCIETY OF THE PLASTICS INDUSTRY, annual national conference and Pacific Coast plastics exposition. Los Angeles. Mar 18-21.

SOCIETY OF AUTOMOTIVE ENGINEERS, production meeting and forum. Buffalo, N. Y. Mar 20-22.

AMERICAN SOCIETY OF TOOL ENGINEERS, technical meeting and convention. Houston, Tex. Mar 25-27.

AMERICAN SOCIETY FOR METALS, Western Metals Congress and Exposition. Los Angeles. Mar 25-29.



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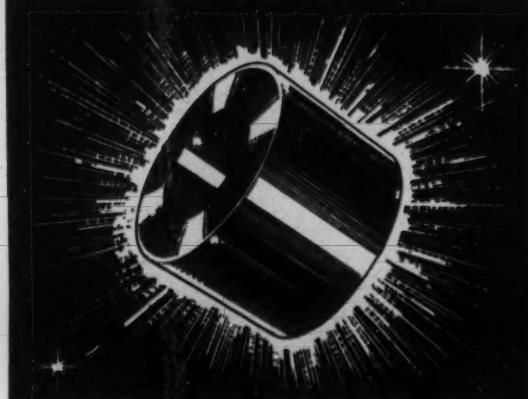

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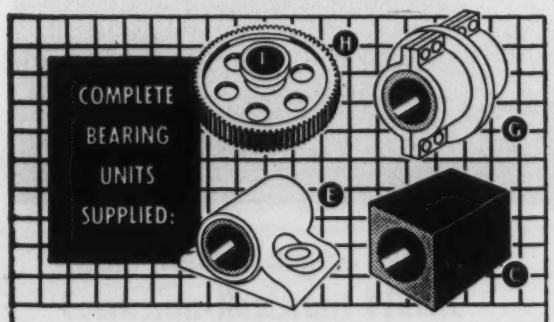

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BOOKS & REPORTS

Books

Proceedings of the 1956 Electronic Components Symposium. *Engineering Publishers, GPO Box 1151, New York 1, N. Y. 8½ by 11 in., 240 pp. Cloth $8.25. Paper $5.*

Contained in this book are papers given at the seventh national meeting on electronic component parts and materials. Using the theme, "Components—Accomplishments and Trends," the papers cover a wide variety of subjects such as materials progress, electron tubes, solid state devices and passive components.

The book contains information about both new and conventional types of components under such titles as "The Effects of Nuclear Radiation on Electronic Components," "Ceramic Transformers and Filters," and "Ferrites for Use in S-Band Microwave Components."

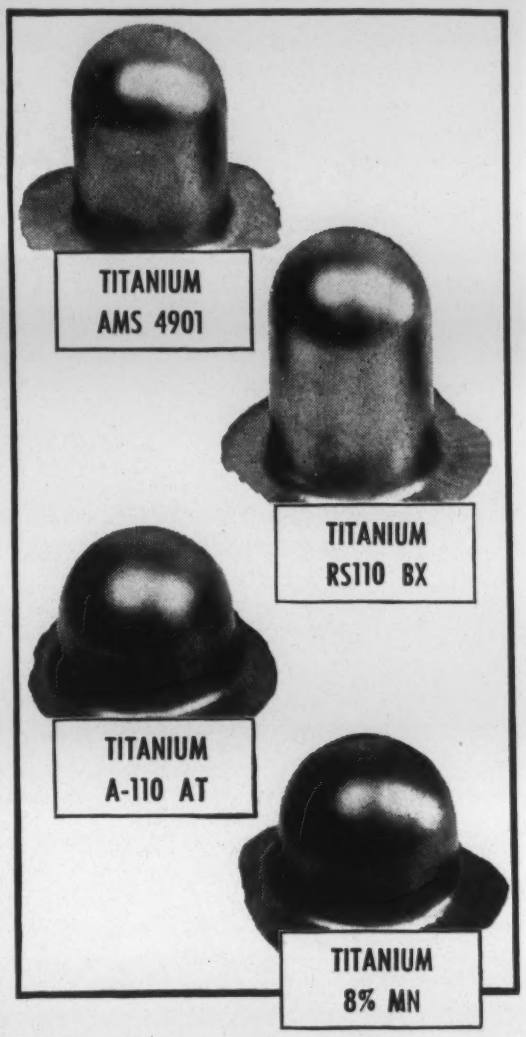
A section on materials discusses new glasses and their electrical component applications; positive temperature coefficient of resistance thermistor materials for electronic applications; properties of piezoelectric titanates and zirconates, including a discussion on their control and evaluation; glass in high temperature components; and standards for capacitor paper.

Photoconductivity Conference. *Edited by R. G. Breckenridge, B. R. Russell and E. E. Hahn. John Wiley & Sons, Inc., New York 16, N. Y. 1956. Cloth, 6 by 9¼ in., 653 pp. Price $13.50.*

This book contains 30 papers by 45 authorities on solid state physics, including basic theory, phenomenological theory, interpretation of photoconduction phenomena, and up-to-date information on photoconducting materials.

The electronic, optical and photoconducting properties of silicon and germanium, as well as the electrical and photoconductive properties of gold-doped germanium, are given. The intermetallic compounds indium antimonide, gallium antimonide and lead sulfide are also discussed.

(Reports on p 231)



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BOOKS & REPORTS

Reports

Oil resistant rubber DEVELOPMENT OF HIGH TEMPERATURE OIL RESISTANT RUBBER. *William J. Mueller, Louis E. Novy, Richard A. Clark and Randall G. Heiligmann, Battelle Memorial Institute. Dec. 1955. 96 pp, graphs, tables. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. $2.50 (PB 121195)*

Describes the development of a rubber for use in synthetic hydraulic fluids, whereas previous reports emphasized the development of a rubber for use in diester type lubricants such as Turbo Oil-15. Covers scope of program, rubber properties desired and suggested approaches to the problem.

Material damping BIBLIOGRAPHY OF THE MATERIAL DAMPING FIELD. *L. J. Demer, University of Minnesota. June 1956. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. $2.75 (PB 121437)*

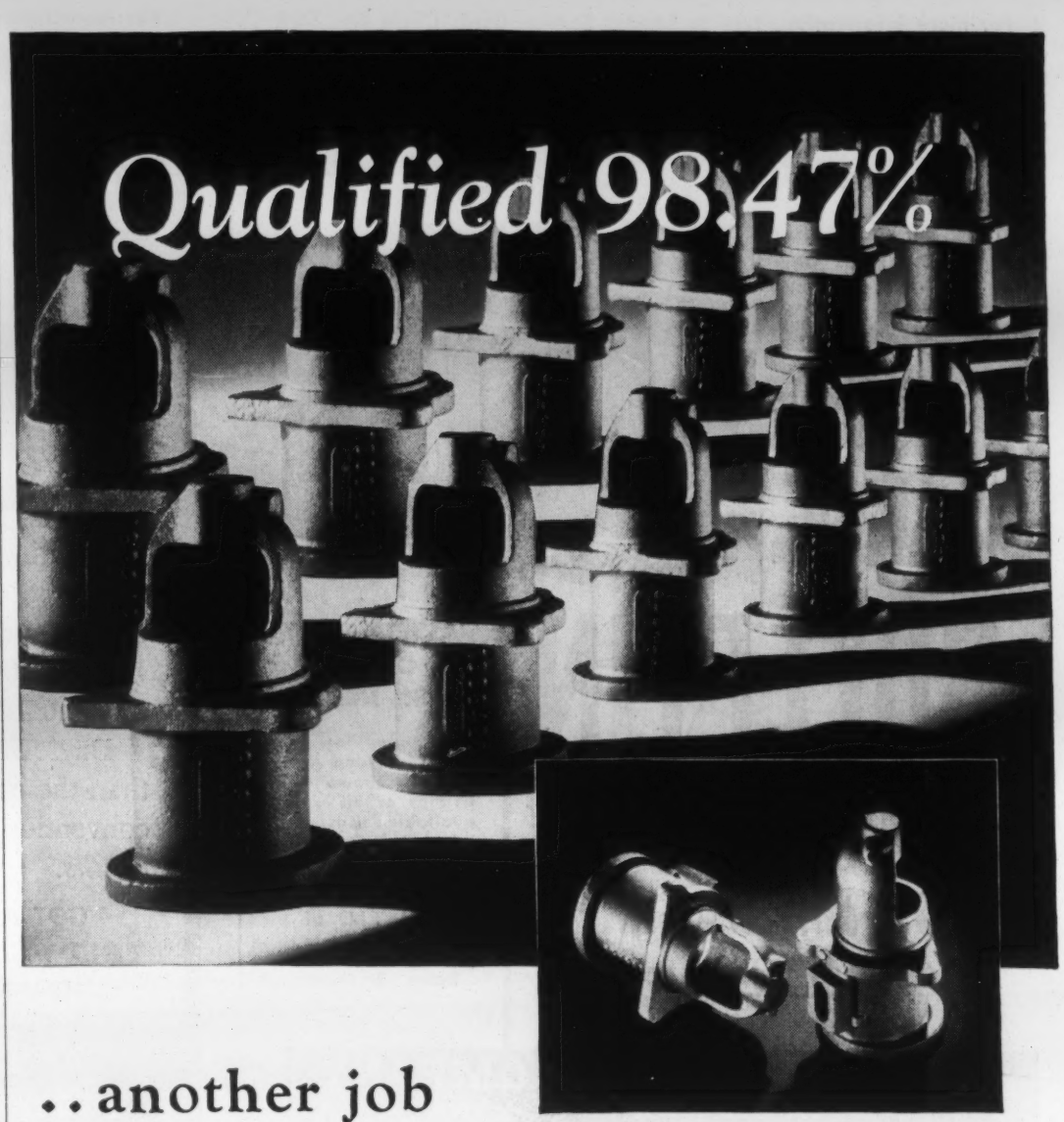
Contains 900 entries which are arranged chronologically. Abstracts are included for all but a few references. A detailed classification system similar to the ASM-SIA Metallurgical Literature Classification is described. Punched card codings are included with each reference.

Degassing aluminum alloys EFFECT OF VACUUM DEGASSING ON PROPERTIES OF VARIOUS ALUMINUM ALLOYS. *E. E. Layne and J. F. Bishop, Naval Research Laboratory. July 1956. 12 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. 50 cents (PB 121325)*

Although mechanical properties are improved by the presence of grain refining additions and by rapid solidification such as occurs in thin sections and chill molds, further improvements in tensile strength, yield strength and elongation are effected by vacuum degassing.

Brittle failure of steel AN INVESTIGATION OF THE EFFECTS OF HYDROGEN ON THE BRITTLE FAILURE OF HIGH STRENGTH STEELS. *E. R. Slaughter, E. E. Fletcher and others. Battelle Memorial Institute. Apr 1956. 59 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. $1.50 (PB 121357)*

Minimum stress necessary for brittle delayed failure of high strength steel is relative to the hydrogen content of the steel.



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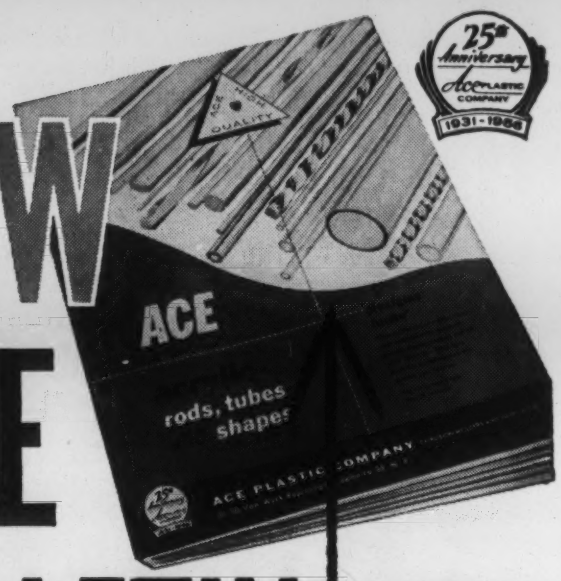

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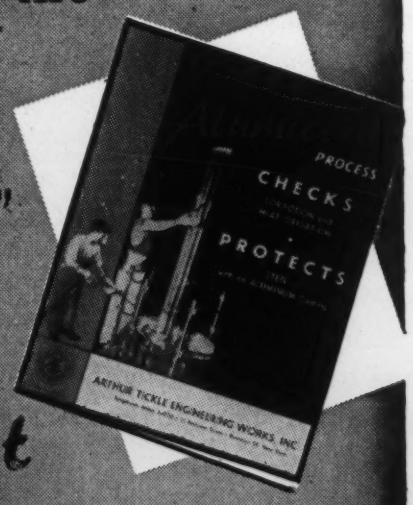

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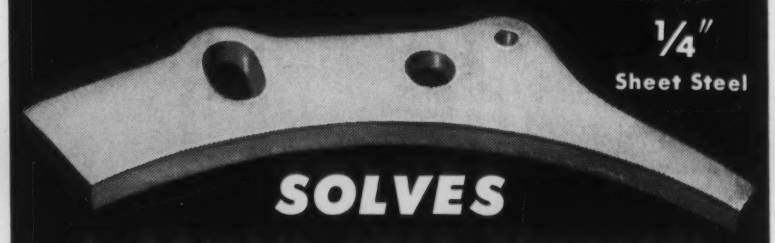

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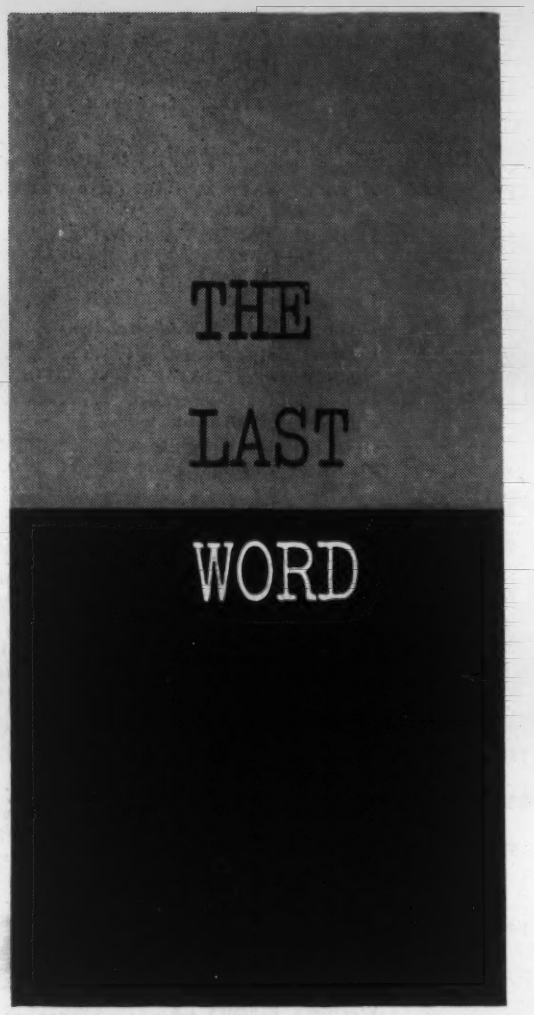

by ***H. R. Clauser,*** *Editor*

A New Year, a New Look

Now that you have gone through this issue (unless like many you start reading magazines from the back) you must have noticed a number of changes, and we hope improvements, in our editorial departments.

One of our new features is the Prices & Supply Department. It includes what we believe is the only prices page in the world listing in one place current price levels of all important engineering materials (see page 188). The listings, we hope, will help you in making cost comparisons of the materials you are considering for your products.

Another important factor many of you must consider when selecting engineering materials is availability. So to keep you informed on the future outlook for materials supply as well as prices, we have engaged Herman B. Director, a consultant in Washington, to write a monthly review and forecast. His first column appears on page 185. Mr. Director is well qualified for the job. For many years he served the government in various capacities as a materials specialist. He now heads up his own consulting firm in Washington and produces a quarterly materials forecast for industry.

A Fat Problem

As magazines become fatter the problem of finding your way around in the back of them becomes progressively more difficult. We have tried to do something positive about this by combining most of what used to be three scattered departments (New Materials, Contents Noted and Materials Engineering News) into a new department which we have titled "What's New in Materials." It starts on page 3 with a quick glance at latest developments and then carries over to page 147 where you will find a complete contents page to help you more quickly find particular items you are interested in.

In case you missed the Materials at Work department which in the past has been located in the feature section, it can now be found in the front of the book starting on page 9. And finally, be sure to take a look at our new News of Industry department starting on page 203.

Engineers Have Long Fatigue Life

The other day I came across something related to the domestic life of engineers which I'm sure you will be interested in. M. D. Hooven, president of the American Institute of Electrical Engineers, reports that the divorce rate of engineers is "startlingly low"—only 2% as compared to the national average of 25% for all husbands.

Last month in this column, you may recall I ventured the opinion that engineers as a group are foolhardy. I cited as proof the fact that a technical society was planning to feature on their ladies' night program a talk on poisonous materials. In light of this new statistic on the divorce rate, I think I must now add to my estimate of the engineer. He is not only foolhardy, as I said last month, but he is also trustworthy, loyal, helpful, friendly, courteous, kind, obedient, cheerful, thrifty, brave, clean and reverent.

Almost a Ton of Bricks

One of the fight fan's favorite expressions, "he hits like a ton of bricks," has now been disproved by science. Recently the force of middleweight ex-champ Sugar Ray Robinson's right cross was measured by an electronic gadget used in our guided missile program. The blow was found to land with a force of 1500 lb. Therefore, we must now revise the expression to read, "he hits like a ¾ ton of bricks."